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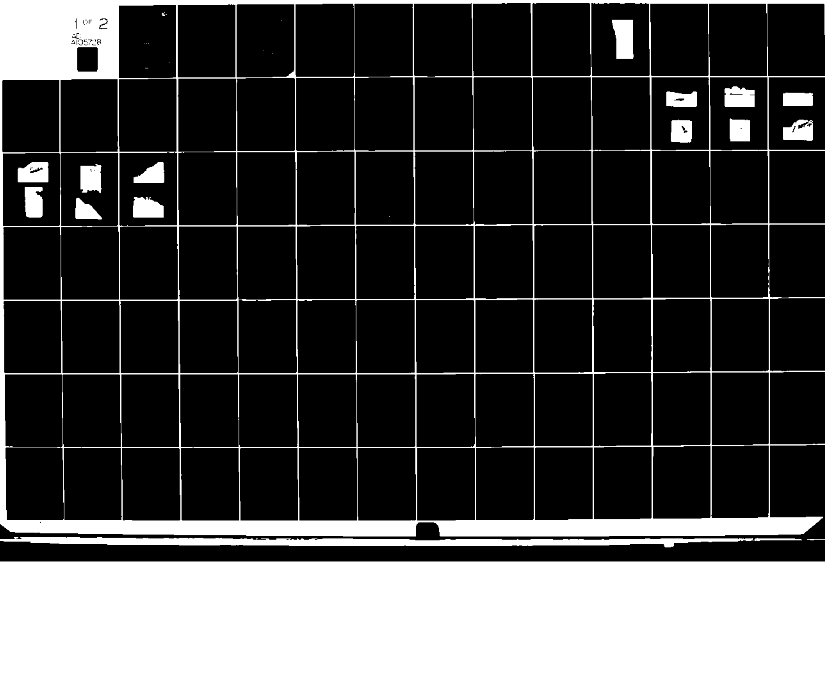

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LEVEL II

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LOWER HUDSON RIVER BASIN

CHURCHTOWN DAM

COLUMBIA COUNTY, NEW YORK
INVENTORY NO. N.Y. 79

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Churchtown Dam (Inventory Number NY. 79), Lower Hudson River Basin, Columbia County, New York. Phase I Inspection Report,

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Churchtown Dam
Columbia County
Lower Hudson River Basin

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

Visual inspection of this dam and engineering analyses which have been performed revealed that several serious deficiencies exist with this structure.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Structural stability analyses, based on available information, indicate that this dam is marginally stable under normal loading conditions and is unstable when subjected to severe loading conditions (such as flood flows or ice loading). Seepage noted under and through the structure, creating wet, soft areas along the downstream toe along both ends of the dam, adversly affect the stability of the structure.

Using the Corps of Engineer's Screening Criteria for the initial review of spillway adequacy, it has been determined that the structure would be overtopped by all storms exceeding 45% of the Probable Maximum Flood (PMF). Stability analyses indicate that the dam is unstable when subjected to overtopping. A dam break analysis performed for this structure indicates that an overtopping induced dam failure would significantly increase the hazard to loss of life downstream of the dam from that which would exist just prior to failure. Therefore, the spillway is adjudged as "seriously inadequate" and the dam is assessed as "unsafe, non-emergency".

Immediately upon receipt of this notification, a system for providing around-the-clock surveillance of the dam during periods of unusually heavy precipitation should be developed and implemented. An emergency action plan for the notification of downstream residents should also be developed.

It is recommended that within 3 months of the date of notification of the owner, investigations into the deficiencies on this structure should be commenced. Studies of the structural stability and seepage problems, including subsurface and structural explorations are necessary. Information obtained should be incorporated into a detailed stability evaluation.

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CHURCHTOWN DAM
I.D. No. NY 79
LOWER HUDSON RIVER BASIN
COLUMBIA COUNTY, NEW YORK

TABLE OF CONTENTS

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Churchtown Dam (I.D. No NY 79)
State Located:	New York
County:	Columbia
Watershed:	Lower Hudson River Basin
Stream:	Unnamed tributary of Taghkanic Creek
Date of Inspection:	October 29, 1980

ASSESSMENT

Visual inspection of this dam and engineering analyses which have been performed revealed that several serious deficiencies exist with this structure.

Structural stability analyses, based on available information, indicate that this dam is marginally stable under normal loading conditions and is unstable when subjected to severe loading conditions (such as flood flows or ice loading). Seepage noted under and through the structure, creating wet, soft areas along the downstream toe along both ends of the dam, adversly affect the stability of the structure.

Using the Corps of Engineer's Screening Criteria for the initial review of spillway adequacy, it has been determined that the structure would be overtopped by all storms exceeding 45% of the Probable Maximum Flood (PMF). Stability analyses indicate that the dam is unstable when subjected to overtopping. A dam break analysis performed for this structure indicates that an overtopping induced dam failure would significantly increase the hazard to loss of life downstream of the dam from that which would exist just prior to failure. Therefore, the spillway is adjudged as "seriously inadequate" and the dam is assessed as "unsafe, non-emergency".

Immediately upon receipt of this notification, a system for providing around-the-clock surveillance of the dam during periods of unusually heavy precipitation should be developed and implemented. An emergency action plan for the notification of downstream residents should also be developed.

It is recommended that within 3 months of the date of notification of the owner, investigations into the deficiencies on this structure should be commenced. Studies of the structural stability and seepage problems, including subsurface and structural explorations are necessary. Information obtained should be incorporated into a detailed stability evaluation.

Additional hydrologic/hydraulic investigations are also needed to find a method to correct the spillway inadequacy. These studies should be performed in a conjuction with the stability analyses to determine the proper mitigating measures needed in response to the seriously "inadequate spillway" assessment. Remedial measures deemed necessary as a result of these investigations should be completed within 18 months.

Other deficiencies noted on this structure should also be corrected within 18 months. Among the actions required are repairing deteriorated concrete on the structure, removing trees, brush and vines growing on the dam and at the downstream toe and making the valve on the 18 inch reservoir drain pipe operable.

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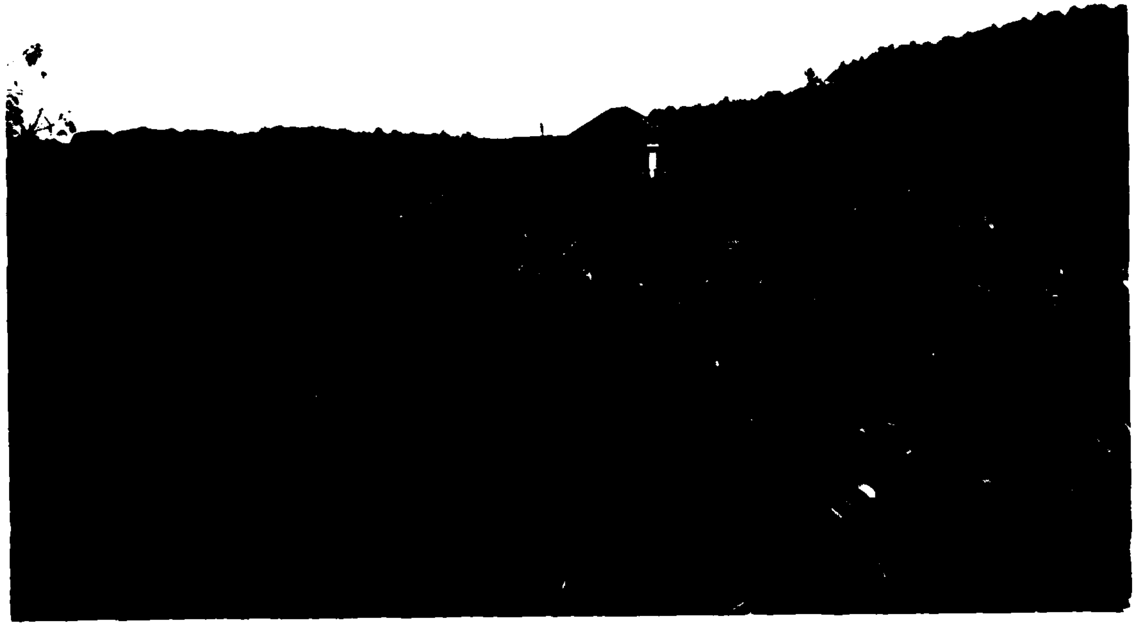
Chief, Dam Safety Section
New York State Department
of Environmental Conservation
NY License No. 45937

Approved By:

Col. W. M. Smith Jr.
New York District Engineer

Date: 14 MAY 1981



OVERVIEW
CHURCHTOWN DAM
I.D. No. NY 79

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CHURCHTOWN DAM
I.D. No. NY 79
#228A-1009
LOWER HUDSON RIVER BASIN
COLUMBIA COUNTY, NEW YORK

SECTION 1: PROJECT INFORMATION

1.1 GENERAL

a. Authority
The Phase I inspection reported herein was authorized by the Department of the Army, New York District, Corps of Engineers, to fulfill the requirements of the National Dam Inspection Act, Public Law 92-367.

b. Purpose of Inspection
This inspection was conducted to evaluate the existing conditions of the dam, to identify deficiencies and hazardous conditions, to determine if these deficiencies constitute hazards to life and property, and to recommend remedial measures where required.

1.2 DESCRIPTION OF PROJECT

a. *Description of Dam*
The Churchtown is a cyclopean masonry dam with an overflow spillway near the center of the structure.

The dam is 425 feet long and a maximum of 44 feet high. The crest width of the dam is 5 feet. The spillway section is 43 feet long with a crest elevation 3.8 feet below the top of the dam. There are provisions for flashboards across the spillway section but none are presently in place.

There is a gate house on the crest of the dam which contains the control mechanisms for four gates. One of these gates controls flow through a 16 inch water main leading to the chlorination plant. This gate is the only one operated regularly.

There is an 18 inch blowoff pipe through the base of the dam which was intended to act as a reservoir drain. However, the gate which controls flow through this pipe is reported to be inoperable.

b. Location
This dam is located on Reservoir Road in the Town of Taghkanic. It is approximately 3/4 mile south of the Village of Churchtown and 1 1/4 miles east of Glenco Mills.

c. Size Classification
This dam is 44 feet high and has a storage capacity of 308 acre-feet. Therefore, the dam is in the intermediate size category as defined by the "Recommended Guidelines for Safety Inspection of Dams".

d. Hazard Classification
The dam is classified as "high" hazard due to the presence of several houses downstream of the dam, as well as the damage which a dam break might cause near the Village of Glenco Mills.

e. Ownership
This dam is owned by the City of Hudson, New York. Mr. Charles Butterworth, Superintendent of Public Works, was contacted concerning the inspection. His address is 520 Warren Street, Hudson, New York 12534. His phone number is (518) 828-9458.

f. Purpose of Dam
This dam impounds a reservoir used for water supply by the City of Hudson.

g. Design and Construction History
This dam was constructed in 1908 by Hurd, Sherman & Company, Contractors. Mr. Cornelius C. Vermuele of New York designed the dam and provided construction supervision. Mr. H.E. Bishop, a former Chief Engineer of the Hudson Water Works also assisted in the design.

Leakage through the structure became a problem soon after the construction. This problem was studied in 1912 by Johnson and Fuller, Consulting Engineers, of New York and by Robert Horton, Consulting Hydraulic Engineer, of Albany. Further studies were performed in 1914 by Nicholas Hill, Consulting Engineer, of New York. He made recommendations and prepared plans for the repair of the structure. This work was performed in 1914 and consisted of the construction of a 6 inch thick reinforced concrete cutoff wall on the upstream face of the dam.

The leakage again reached unacceptable levels in 1957. The owner engaged Barker and Wheeler, Consultants, of Albany to make necessary investigations, plans and specifications for repairs. It is believed that these repairs were made and the leakage was reduced.

h. Normal Operating Procedures
There are no prescribed operating procedures for this structure. Water is withdrawn from the reservoir as required by the owner.

1.3 PERTINENT DATA

a. Drainage Area (acres)			683
b. Discharge at Dam (cfs)			
Spillway at Maximum High Water (without flashboards)			758
Spillway at Maximum High Water (with flashboards)			508

c. Elevation	(Plan)	(USGS)	(Field)
Top of Dam	423	428	+3.8
Spillway Crest	420	425	0

d. Reservoir-Surface Area (acres)	
Top of Dam	18
Spillway Crest	15
e. Storage Capacity (acre-feet)	
Top of Dam	308
Spillway Crest	251

f. Dam
Type - Cyclopean masonry (concrete containing boulders at least 8 cu. ft. in size); Constructed in sections 50 feet long by 3 foot high.

Dam Length (ft)	425
Crest Width (ft)	5

g. Spillway
Type: Ungated, concrete overflow weir located near center of dam; Provisions for up to 1 foot of flashboards (2 inch pipes, 4 foot on centers)

Length: (ft) 43

h. Low-Level Outlets
Type: 16 inch water supply pipe; 18 inch blow off pipe
Control: Valve Control mechanisms located in gate house;
Valve for 16 inch pipe operable, valve for 18 inch pipe is inoperable.

i. Appurtenant Structures-Gatehouse
Brick Structure on crest of dam; contains control mechanism for 4 gates; only one of which is operated regularly.

SECTION 2: ENGINEERING DATA

2.1 GEOTECHNICAL DATA

a. Geology

The Churchtown Dam is located near the boundary of the Hudson lowlands physiographic province and the Taconic uplands physiographic province of New York State. The Hudson lowlands is an area 15 to 20 miles wide near the Hudson River which is underlain by weak sedimentary rocks. The lowlands in this vicinity have a narrow inner valley with a conspicuous terrace and gently rolling hills and ridges beyond this terrace. Rock underlying the Taconic uplands include limestones, sandstones and slates altered by faulting and folding. These mountains merge into the gently rolling hills at the edge of the Hudson lowlands. The surficial soils and features of the area are the result of glaciations during the Cenozoic Era, the last of which was the Wisconsin glaciation.

A review of the "Brittle Structures Map of the State of New York" indicates that there are no faults in the immediate vicinity of the dam; There is a high angle reverse fault approximately 1/4 mile west of the dam.

b. Subsurface Investigations

No records of any subsurface investigations performed in the vicinity of this structure could be located.

2.2 DESIGN RECORDS

No records from the original design of this structure were available. However, reports prepared both in 1912 and 1914 provided some information about the original design. The leakage problem caused concern for the stability of the structure and so these reports reviewed the structural stability computations performed by the designer, Mr. C.C. Vermuele. Further stability analyses were also performed by the engineers who prepared these reports, Mr. Nicholas Hill, who prepared the 1914 report, also designed modifications needed to repair the leakage. Plans for these modifications were available.

2.3 CONSTRUCTION RECORDS

The 1912 and 1914 reports as well as a 1905 magazine article (Engineering Record-April, 1905; see Appendix C) provide the only construction records available. These sources provide some information about the dam's foundation and about the concrete used in the structure.

2.4 OPERATIONS RECORDS

Water level readings for this reservoir are taken only when the water level drops below the spillway crest.

2.5 EVALUATION OF DATA

Data used for the preparation of this report was obtained from the Department of Environmental Conservation files and from the City of Hudson's Department of Public Works. The information available appeared to be reasonably accurate.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General

Visual inspection of the Churchtown Dam was conducted on October 29, 1980. The weather was overcast and the temperature was around 45 degrees. The water level at the time of the inspection was 0.1 feet above the spillway crest.

b. Dam

The visual inspection of the dam revealed a number of deficiencies on this structure. The most serious of these was seepage noted along the downstream toe on either side of the spillway. On the right side of the spillway, there was seepage and a soft area which extended for a distance of about 30 feet along the toe. The ground was very soft in an area which extended out about 15 feet from the toe. There was concentrated seepage noted at only one point but the total volume observed indicated that there was more than just one source of concentrated seepage. On the left side of the spillway, seepage was emerging from the downstream face of the dam. There was a wet area which extended for approximately 50 feet and covered the lower third of the downstream face. A soft wet area was noted out and away from the downstream toe on this section as well. This area extended from a point near the abutment where the seepage commenced over to the outlet channel of the spillway, a distance of about 150 feet.

Overall concrete deterioration was evident on this structure. There was spalling and surface cracking of the thin layer of concrete which covered the downstream face. More substantial structural cracking was noted on the upstream face at the right abutment. There was also concrete removal in this area. Spalling concrete was noted along the crest of the dam as well.

There was brush growing along much of the downstream toe of the dam. Some brush and vines were actually growing out of the downstream face. There were also vines growing along the upstream face at the left end of the dam.

c. Spillway

There was deteriorated concrete on the spillway. Several small voids were noted on the downstream face. There was significant concrete removal on the walls at either end of the spillway section which separate it from the nonoverflow segment of the dam. There were no stop logs in place at the time of inspection, but 2 inch diameter pipe supports, 4 feet on centers, were in place.

d. Low level Outlets

The low level outlet consists of a 16 inch diameter pipe loading to the chlorination plant downstream of the dam. The gate valve controlling flow through this pipe is operated regularly. The remaining 3 gates whose control mechanisms are located in the gate house are not regularly operated. The gate on the 16 inch pipe is closed and the pipe is cleaned once each year. Therefore, this gate is operable and the valve can be closed tightly. The gate on the 18 inch blow off pipe at the base of the dam was not operable.

e. <u>Appurtenant Structures-Gatehouse</u>
The gatehouse structure on the crest of the dam was in satisfactory condition.

3.2 EVALUATION OF OBSERVATIONS

Visual observations revealed several deficiencies on this structure. The following items were noted:

1. Seepage appearing on the donwstream face of the dam, at the downstream toe and beyond the toe.

2. Concrete deterioration on the non-overflow section including spalling, cracking, and some concrete removal.

3. Deteriorated concrete on the walls separating the spillway section from the non-overflow section.

4. Trees, brush, and vines growing on the dam and at the downstream toe.

5. The valve on the 18 inch blow off drain pipe was not operable.

SECTION 4: OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES

Water is withdrawn from the reservoir as required. The valve on the 16 i pipe leading to the chlorination plant downstream of the dam is fully clo once a year, and the pipe is cleaned. No leakage occurs through the valv during the shutdown. Water level readings are taken daily, when the pool drops below the spillway crest. No water level records are kept at other times. There are provisions for flashboards on the spillway but they are no longer used.

4.2 MAINTENANCE OF DAM

Normal maintenance is performed as required by the City of Hudson's Depar of Public Works. Information in the files indicate that several times si its construction more substantial repairs have been required on this str Repairs were made in 1914 and again in 1957 to reduce the seepage through dam.

4.3 WARNING SYSTEM IN EFFECT

No apparent warning system for evacuation of downstream residents is pres

4.4 EVALUATION

The operation procedures for this dam are satisfactory. Increased mainte efforts are needed to repair the deficiencies noted in Section 3.

SECTION 5: HYDROLOGIC/HYDRAULIC

5.1 DRAINAGE AREA CHARACTERISTICS

The delineation of the contributing watershed to this dam is shown on the map titled "Drainage Area Map - Churchtown Reservoir Dam" (Appendix C). The irregular but somewhat ovalshaped east-west oriented watershed of some 683 acres is comprised of r_latively underveloped lands consisting of open farmland and forests. Slopes are moderate to steep with the hilltops ranging from 200 to 400 feet in elevation above the reservoir. There are no other major bodies of wat ~ within the watershed.

5.2 ANALYSIS CRITERIA

The analysis of the flood water retarding capability of the dam was performed using the Corps of Engineers HEC-1 computer program, Dam Safety version, and data provided by the report titled "Lower Hudson River Basin Hydrologic Flood Routing Model" (Appendix C, ref. 4). The computer program develops an ivflow hydrograph using the "Snyder Unit Hydrograph" method and then reservoir routs the hydrograph using the "modified Puls" flood routing procedure. The spillway design flood selected for analysis was the Probable Maximum Flood (PMF), in accordance with the Recommended Guidelines of the U.S. Army Corps of Engineers. The PMF event is that hypothetical storm event resulting from the most critical combination of rainfall, minimum soil retention, and direct runoff to a specific site that is considered reasonably possible for a particular watershed.

5.3 SPILLWAY CAPACITY

The 43 foot long single, ungated, concrete overflow weir is located near the center of the dam. Although provisions for flashboards exist, they were not in place at the time of inspection. Spillway flashboards, 12 inches high, have been used in the past. However, during flood events, the spillway capacity would be decreased if such flashboards remained in place. The spillway was analyzed for weir flow using a discharge coefficient, C, varying from 3.10 to 3.42. The computed discharge capacity of the spillway is 758 cfs and 508 cfs with flashboards.

The flood analysis performed for this dam indicates that the spillway without flashboards does not have sufficient capacity for discharging one-half the PMF. For this storm event, the peak inflow is 896 cfs and the peak outflow is 887 cfs. The PMF peak inflow is 1792 cfs and the peak outflow is 1783 cfs.

5.4 RESERVOIR CAPACITY

The normal water surface is at or near the spillway crest (elev. 425). The impounded capacity for this elevation is 251 acre-feet. Surcharge storage capacity to the top-of-dam (elev. 428.8) adds 57 acre-feet which is equivalent to a direct runoff depth of 1.0 inch over the watershed. The total storage capacity is 308 acre-feet.

5.5 FLOODS OF RECORD

The date of occurrence of the maximum flood is not known. However, for the Claverack Creek/Taghkanic Creek watershed in which this dam is located, a maximum discharge of 4960 cfs was recorded downstream of the site on

June 30, 1973. The flow gage had a contributing area of 60.6 square miles. Although no flow gage exists for the dam site, a preciptation recording gage does exist. The hourly rainfall amounts for this storm event are included in Appendix C.

5.6 OVERTOPPING POTENTIAL

Analysis using the PMF and one-half PMF storm events indicates that the dam does not have sufficient spillway capacity. The computed depths of overtopping for these two events are 0.81 feet and 0.18 feet respectively. All storm events exceeding 45% of the PMF will result in the dam being overtopped.

5.7 EVALUATION

The spillway capacity is inadequate for the peak outflow from one-half PMF and the structural stability analysis indicates the dam could fail during this same storm event. Therefore, a dam-break analysis, assuming a breaching of the dam, was performed. The analysis indicates that water surface levels downstream of the dam could reach depths which would pose a significant danger to residents. That is, dam failure resulting from overtopping would significantly increase the hazard to loss of life downstream from the dam from that which would exist just before an overtopping failure. Therefore, the spillway is adjudged as"seriously inadequate" and the dam is assessed as "unsafe, non-emergency".

SECTION 6: STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

Visual inspection of this structure revealed several deficiencies which affect the stability of this structure. There was seepage emerging at the toe of the dam on the right side of the spillway. This seepage caused a soft area beyond the toe which was about 30 feet long. On the left side of the spillway, seepage was emerging from the lower third of the downstream face in an area which extended for approximately 50 feet.

b. Data Review and Stability Evaluation

Information reviewed include two reports which contained independent stability analyses performed for this structure. These reports were prepared in response to the seepage problems on this dam. They stated that the original design assumed no uplift pressure beneath the dam, no ice load, and a water level at the spillway crest. Both reports indicated that when appropriate factors were taken into account, the dam was only marginally stable. The conclusion of both reports was that the uplift pressure had to be reduced to achieve adequate factors of safety. The construction of the 6 inch thick cutoff wall in 1914 was intended to eliminate the seepage.

A stability analysis was performed for this report in accordance with the "Recommended Guidelines for the Safety Inspection of Dams". This analysis assumed full uplift pressure on the upstream face decreasing to the tailwater pressure at the downstream face, and an ice load of 5000 pounds per linear foot. The analysis was based on a cross section of the dam shown in the 1905 magazine article (See Appendix C). Separate analyses were performed assuming a failure plane along the dam's foundation and through the middle of the structure. The results are as follows:

	Full Dam Section			Failure Through Middle of Dam		
Case	Overturning Safety Factor	Resultant in Middle Third	Sliding Safety Factor	Overturning Safety Factor	Resultant in Middle Third	Sliding Safety Factor
a. Normal conditions; water surface at spillway crest.	1.29	NO	1.05	2.08	YES	1.39
b. Case a plus an ice load of 5,000 #/ft.	1.11	NO	0.96	1.27	NO	0.94
c. 1/2 PMF flow; water surface 0.18 feet over top of dam	1.08	NO	0.87	1.46	NO	0.91
d. PMF flow; water surface 0.81 feet over top of dam	1.06	NO	0.84	1.40	NO	0.86
e. Normal conditions with seismic co-efficient of 0.10.	1.20	NO	0.81	1.96	YES	.98

These analyses indicate that the dam is marginally stable under normal conditions and would be unstable under severe loading conditions. The sliding safety factor under these conditions falls below 1.0 for both failure planes analyzed. The fact that this structure has remained in place since 1904 indicates that the actural safety factors may be higher than those calculated. Hence, the structure must be considered as being only marginally stable.

Further investigations are required to better assess the stability of the dam. Subsurface explorations and concrete cores, to obtain information about the condition of the structure and the uplift forces are required. Accurate cross sections of the dam should also be obtained. Stability analyses should then be performed using this data. Based on the results of these analyses, required modifications to the structure should be made.

<u>c. Seismic Stability</u>
This structure is located in Seismic Zone 2. A seismic stability analysis was performed for both failure planes, assuming a seismic coefficient of 0.1. The results of this analysis (shown on page 10) indicate that the safety factors against sliding are below 1.0 when seismic considerations are included.

SECTION 7: ASSESSMENT/RECOMMENDATIONS

7.1 ASSESSMENT

a. Safety

The Phase I inspection of the Churchtown Dam revealed seepage under and through the structure. Seepage was noted on both downstream sides of the spillway. There were soft areas which extended for more than 30 feet along the toe on either side. This seepage adversly affects the stability of the structure.

The inspection also revealed that the stability of this structure is questionable. Analyses performed indicated that the structure is only marginally stable under normal loading conditions and is unstable when subjected to severe loading conditions (such as flood flows or ice loading).

The spillway capacity for this dam has been rated as seriously inadequate since it is not capable of passing one-half the Probable Maximum Flood without overtopping the dam. Stability analyses performed indicates that under this loading condition the dam would be unstable. A dam break analysis indicates that an overtopping dam induced failure would significantly increase the hazard to loss of life downstream of the dam. Therefore, the spillway is adjudged as seriously inadequate and the dam is assessed as unsafe, non-emergency.

b. Adequacy of Information

The information which was available for the preparation of this report presented a fairly complete history of the structure. Sketches and plans which were available were design documents and did not reflect modifications made during construction. For this reason, some dimensions shown on the plans did not agree with field measurements made at the time of the inspection.

c. Need for Additional Investigations

Further investigations of the structural stability and the seepage problems on this dam are required. The studies should include subsurface and structural investigations to obtain information about the condition of the structure and its foundation. This data should then be incorporated into a detailed stability evaluation.

Additional detailed hydrologic/hydraulic investigations are also necessary to correct the spillway discharge capacity inadequacy. These studies should consider the site specific characteristics of the watershed, such as additional surcharge storage capacity both within the drainage area and at the dam. These studies should be performed in conjunction with the stability analyses to determine the proper mitigating measures needed in response to the seriously inadequate spillway capacity.

d. Urgency

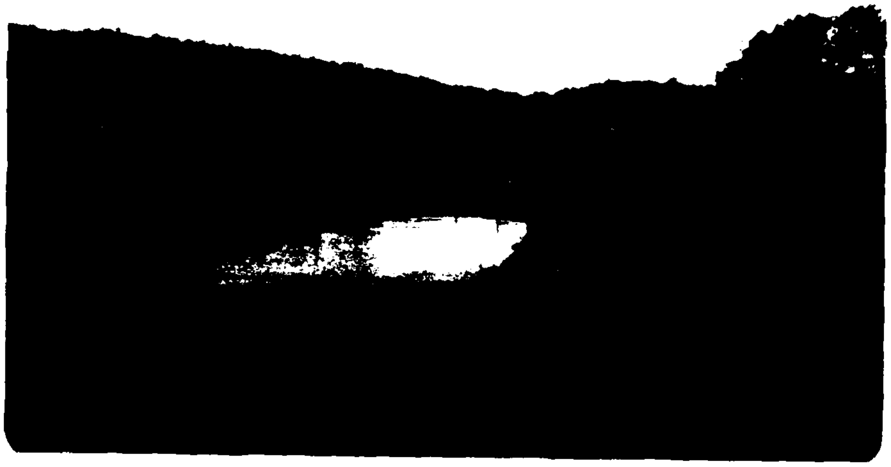
Investigations of the structural stability and seepage problems should be commenced within 3 months of the date of notification of the owner. A detailed hydrologic/hydraulic investigation should be commenced within 3 months. Remedial measures deemed necessary both as a result of these investigations and to correct the other deficiencies noted should be completed within 18 months.

7.2 RECOMMENDED MEASURES

1. Modify the structure as necessary, based on the stability analysis.
2. Take mitigating actions as necessary, based on the hydrologic/hydraulic investigation.
3. Eliminate the seepage coming under and through the dam.
4. Repair deteriorated concrete on both the spillway and the non-overflow section.
5. Remove trees, brush and vines growing on the dam and along the downstream toe.
6. Make repairs to the 18 inch reservoir drain pipe to make it operable.
7. Develop an emergency action plan for the notification of downstream residents.

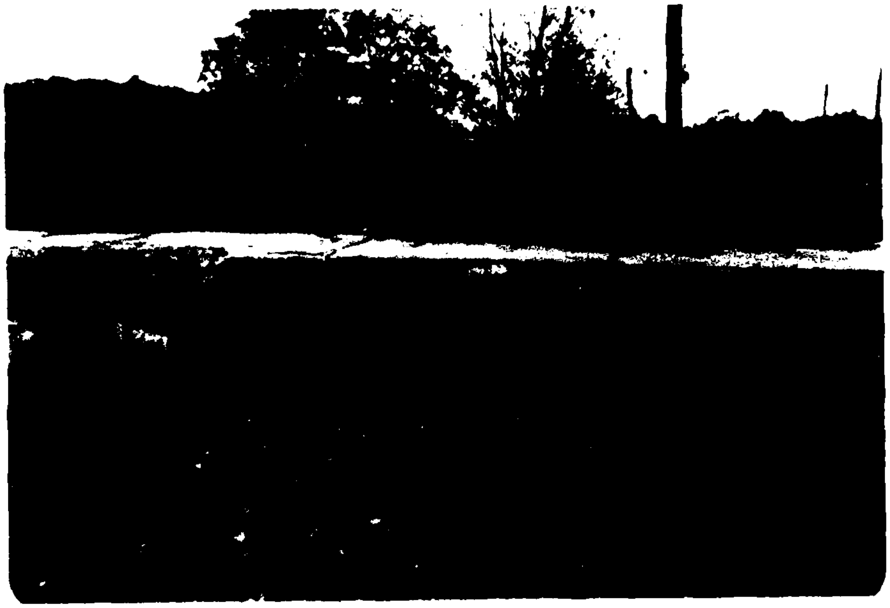
APPENDIX A

PHOTOGRAPHS

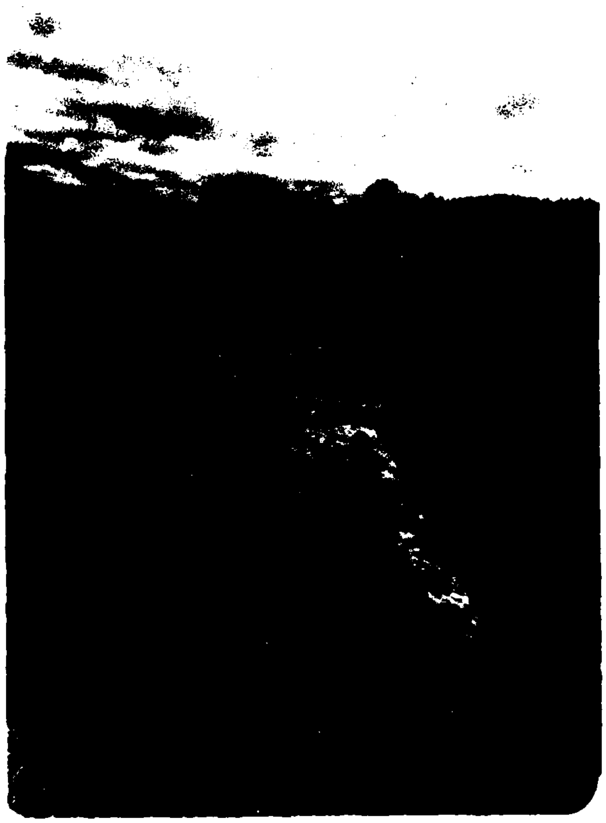


Upstream Face of Dam, Right End

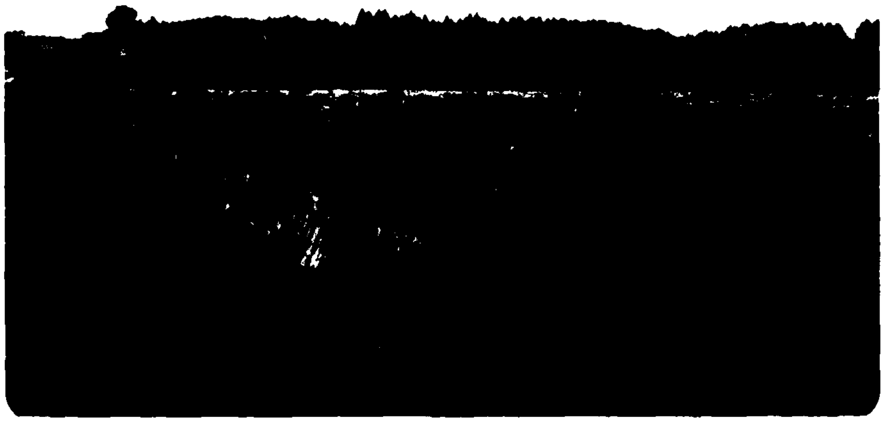
Crest of Dam at Right End



Cracks and Voids in Concrete on Upstream Face
at Right End of Dam



Crest of Dam at Left End - Note Deteriorated
Concrete



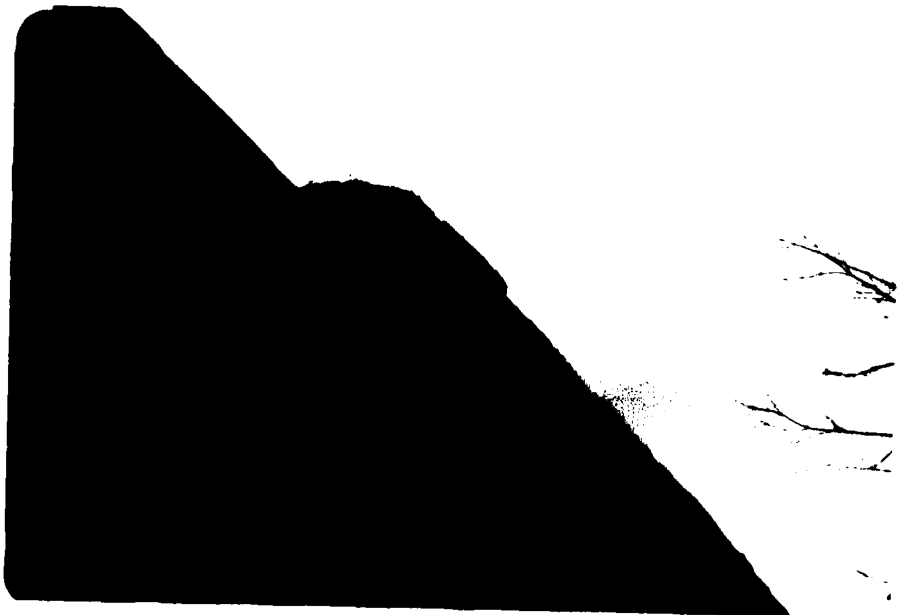
Downstream Face at Left End of Dam; Dark
Area at Base is Seepage

Close - up of Seepage at Base of Left
End of Dam

Downstream Face at Right End of Dam; Seepage
Emerging at Base

View From Crest Looking Down on Seepage
at Right End of Dam

Spillway Crest with Provisions for
Flashboards



Deteriorated Concrete Wall at Left End of Spillway

Deteriorated Concrete on Wall at Right
End of Spillway; Note Brush Growing on Downstream Face

Deteriorated Concrete on Downstream Face
of Dam

APPENDIX B

VISUAL INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST

1) Basic Data

a. General

Name of Dam CHURCHTOWN DAM

Fed. I.D. # 79 DEC Dam No. 228A-1009

River Basin LOWER HUDSON

Location: Town TAGHKANIC County COLUMBIA

Stream Name

Tributary of TAGHKANIC CREEK

Latitude (N) 42° 9.8′ Longitude (W) 73° 43.2′

Type of Dam CONCRETE (CYCLOPEAN MASONRY)

Hazard Category C

Date(s) of Inspection 10/29/80

Weather Conditions OVERCAST 45°

Reservoir Level at Time of Inspection 3.7′ BELOW TOP OF DAM

b. Inspection Personnel R. L WARRENDER W.C. LYNICK

c. Persons Contacted (Including Address & Phone No.)

CHARLES BUTTERWORTH

CITY OF HUDSON, DEPT. OF PUBLIC WORKS

520 WARREN ST.

HUDSON, N.Y. 12534 (518) 828-9458

d. History:

Date Constructed 1904 Date(s) Reconstructed 1914

1957

Designer CORNELIUS VERMUELE, NEW YORK

Constructed By HURD, SHERMAN & COMPANY CONTRACTORS

Owner CITY OF HUDSON

93-15-3(9/80)

(1) Erosion at Contact

(2) Seepage Along Contact

3) Drainage System

a. Description of System NONE

b. Condition of System

c. Discharge from Drainage System

4) Instrumentation (Momumentation/Surveys, Observation Wells, Weirs, Piezometers, Etc.)

NONE

93-15-3(9/80)

5) Reservoir

a. Slopes WOODED & FORESTED TO EDGE

b. Sedimentation NONE APPARENT

c. Unusual Conditions Which Affect Dam NONE

6) Area Downstream of Dam

a. Downstream Hazard (No. of Homes, Highways, etc.) 1 HOME & COUNTY ROAD 1 MILE DOWNSTREAM - SEVERAL HOMES IN GLENCO MILLS

b. Seepage, Unusual Growth SEEPAGE & SOFT SPOTS FOUND BEYOND DOWNSTREAM TOE

c. Evidence of Movement Beyond Toe of Dam NONE

d. Condition of Downstream Channel SATISFACTORY

7) Spillway(s) (Including Discharge Conveyance Channel)

SINGLE OVERFLOW SECTION - LOW LEVEL PIPES - 16 INCH IS OPERABLE

a. General GATEHOUSE CONTAINING CONTROL MECHANISM FOR 4 GATES ONLY 1 OF WHICH IS OPERABLE; LOCATED ADJACENT TO OVERFLOW SECTION - 16 INCH PIPE LEADS TO CHLORINATION PLANT - CAN ACT AS RESERVOIR DRAIN

b. Condition of ~~Service~~ OVERFLOW Spillway - SOME CONCRETE DETERIORATION ON DOWNSTREAM FACE. CONCRETE BADLY DETERIORATED ON WALLS SEPARATING SPILLWAY FROM NON OVERFLOW SECTION

2" PIPES - 4' ON CENTER ACROSS SPILLWAY CHANNEL CAN BE USED TO SUPPORT ~~[illegible]~~ FLASH BOARDS

c. Condition of Auxiliary Spillway ____________

d. Condition of Discharge Conveyance Channel BACKWATER CREATED BY ROAD CULVERT

8) <u>Reservoir Drain/Outlet</u> · WATER SUPPLY PIPE TO CHLORINATION BUILDING

Type: Pipe ✓ Conduit ______ Other ______

Material: Concrete ______ Metal ______ Other ______

Size: 16 INCH Length ______

Invert Elevations: Entrance ______ Exit ______

Physical Condition (Describe): Unobservable ______

Material: ______

Joints: ______ Alignment ______

Structural Integrity: ______

Hydraulic Capability: ______

Means of Control: Gate ✓ Valve ______ Uncontrolled ______

Operation: Operable ✓ Inoperable ______ Other ______

Present Condition (Describe): GATE CLOSED YEARLY & PIPE IS CLEANED

9) Structural

a. Concrete Surfaces OVERALL SPALLING & DETERIORATION
SIGNIFICANT SPALLING OF CONCRETE ALONG CREST

b. Structural Cracking CRACKS IN THIN LAYER OF CONCRETE ON DOWN-STREAM FACE - VINES & BRUSH GROWING ON FACE CAUSING SOME DETERIORATION

c. Movement - Horizontal & Vertical Alignment (Settlement)
NONE

d. Junctions with Abutments or Embankments SATISFACTORY - NO SEEPAGE NOTED IN THESE AREAS

e. Drains - Foundation, Joint, Face NONE

f. Water Passages, Conduits, Sluices UNOBSERVABLE

g. Seepage or Leakage LEFT SIDE OF SPILLWAY - SEEPAGE ±4' ABOVE GROUND - 47' LONG - COMING THROUGH FACE - WET, SOFT AREA BEYOND TOE ABOUT 75' LONG
RIGHT SIDE - SEEPAGE COMING BENEATH DAM - STARTING 64' FROM ABUTMENT WET AREA EXTENDS 32' & 15' OUT FROM D.S. TOE - AREA IS VERY SOFT TO WALK ON.

h. Joints - Construction, etc. SURFICIAL DETERIORATION
PROBABLY MORE SUBSTANTIAL DETERIORATION BENEATH
THIN SURFACE LAYER OF CONCRETE

i. Foundation

j. Abutments SATISFACTORY

k. Control Gates 1 OPERABLE - CONTROLS 16" LINE TO CHLORINATION
PLANT 3 INOPERABLE

l. Approach & Outlet Channels NOT APPLICABLE

m. Energy Dissipators (Plunge Pool, etc.) SATISFACTORY

n. Intake Structures NOT OBSERVED

o. Stability NO VISUAL EVIDENCE OF MOVEMENT

p. Miscellaneous BRUSH GROWING AT DOWNSTREAM TOE & ON FACE
SEVERAL TREES GROWING OUT OF FACE VINES
GROWING OUT OF FACE

10) Appurtenant Structures (Power House, Lock, Gatehouse, Other)

a. Description and Condition

GATEHOUSE - BRICK BUILDING ON CREST - CONTAINS CONTROL MECHANISM FOR 4 GATES

BUILDING IN GOOD CONDITION

11) Operation Procedures (Lake Level Regulation):

FLASHBOARDS NO LONGER USED REGULARLY

WATER LEVELS IN RESERVOIR TAKEN DAILY WHEN WATER LEVEL DROPS BELOW SPILLWAY CREST.

BRUSH IN TAILWATER AREA IS ROOTINELY CLEARED IN THE SUMMER

APPENDIX C

HYDROLOGIC/HYDRAULIC ENGINEERING DATA AND COMPUTATIONS

CHURCHTOWN RESERVOIR
NY-79

CHECK LIST FOR DAMS
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

AREA-CAPACITY DATA:

	(RELATIVE) Elevation (ft.)	Surface Area (acres)	Storage Capacity (acre-ft.)
1) Top of Dam	3.8	—	308
2) Design High Water (Max. Design Pool)	N/A		
3) Auxiliary Spillway Crest	N/A		
4) Pool Level with Flashboards	1.0		
5) Service Spillway Crest	0.0	15	251

DISCHARGES

	Volume (cfs)	
1) Average Daily	N/A	
2) Spillway @ Maximum High Water	758	
3) Spillway @ Design High Water	N/A	
4) Spillway @ Auxiliary Spillway Crest Elevation	N/A	
5) Low Level Outlet	N/A	
6) Total (of all facilities) @ Maximum High Water	758	NO FLASHBOARDS
7) Maximum Known Flood	N/A	
8) At Time of Inspection	4	

CHURCHTOWN RESERVOIR
NY-79

CREST: (RELATIVE) ELEVATION: 3.8

Type: CONCRETE WEIR

Width: 6' Length: 382'

Spillover CONCRETE - SINGLE WEIR

Location NEAR CENTER OF DAM

SPILLWAY:

SERVICE		[redacted]
0.0 (USGS ≈ 425)	(RELATIVE) Elevation	
SHARP-CRESTED WEIR	Type	N/A
6'	Width	
	Type of Control	
✓	Uncontrolled	
	Controlled:	
FLASHBOARD PIPE SUPPORTS EXIST ; NO FLASHBOARDS	Type (Flashboards; gate)	
H L	Number	
0 – 2.8' 39.6' 2.8' – 3.8' 43.6'	[redacted]/Length	
	Invert Material	
	Anticipated Length of operating service	
N/A	Chute Length	
> 20'	Height Between Spillway Crest & Approach Channel Invert (Weir Flow)	

93-15-4(9/80)

CHURCHTOWN RESERVOIR NY-79 3

HYDROMETEROLOGICAL GAGES:

Type : RECORDING RAIN GAGE (NOAA INDEX # 1483)

Location: NEAR DAM

Records:

Date -

Max. Reading -

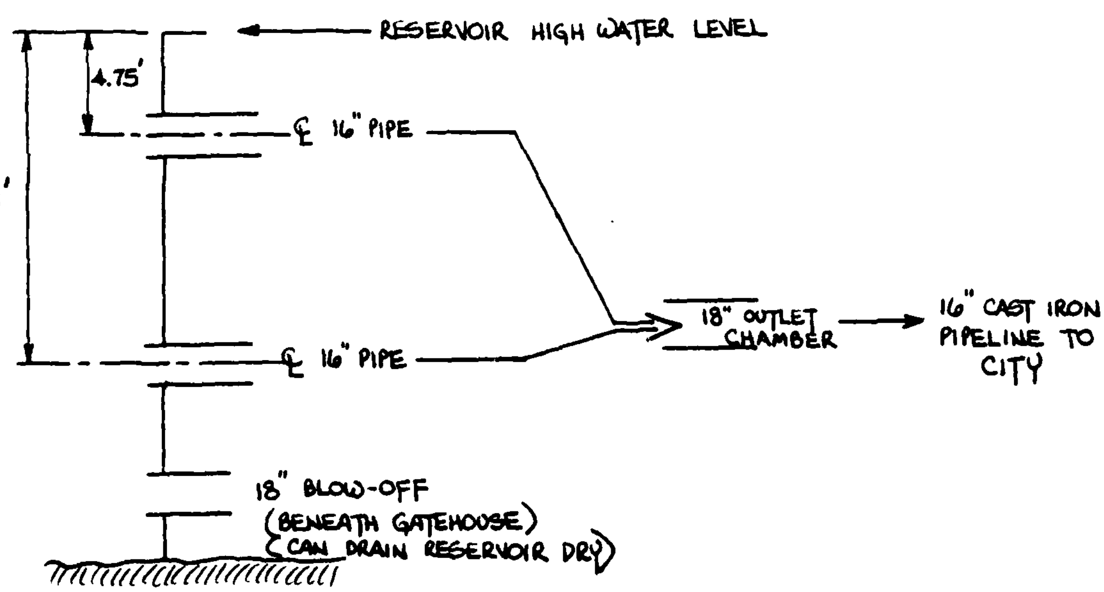
FLOOD WATER CONTROL SYSTEM:

Warning System: N/A

Method of Controlled Releases (mechanisms):

WATER SUPPLY PIPE (16" DIAM.) - GATE CONTROL IN GATE HOUSE 4 GATE STEMS EXIST - ONLY ONE IS REGULARLY OPERATED

FROM ENGINEERING - RECORD
APRIL 1905
pg 371



CHURCHTOWN RESERVOIR
NY-79

DRAINAGE AREA: 1.067 SQ MI. OR 683 ACRES

DRAINAGE BASIN RUNOFF CHARACTERISTICS:

Land Use - Type: UNDEVELOPED ; OPEN FARM FIELDS & FORESTS

Terrain - Relief: MODERATE TO STEEP SLOPES ; HILLTOPS RANGE 200' TO 400' ABOVE RESERVOIR

Surface - Soil: GRAVELS ; LOAM

Runoff Potential (existing or planned extensive alterations to existing (surface or subsurface conditions)

N/A

Potential Sedimentation problem areas (natural or man-made; present or future)

N/A

Potential Backwater problem areas for levels at maximum storage capacity including surcharge storage:

NONE APPARENT

Dikes - Floodwalls (overflow & non-overflow) - Low reaches along the Reservoir perimeter:

Location: N/A

Elevation:

Reservoir:

Length @ Maximum Pool 1350' ≈0.25 (Miles)

Length of Shoreline (@ Spillway Crest) (Miles)

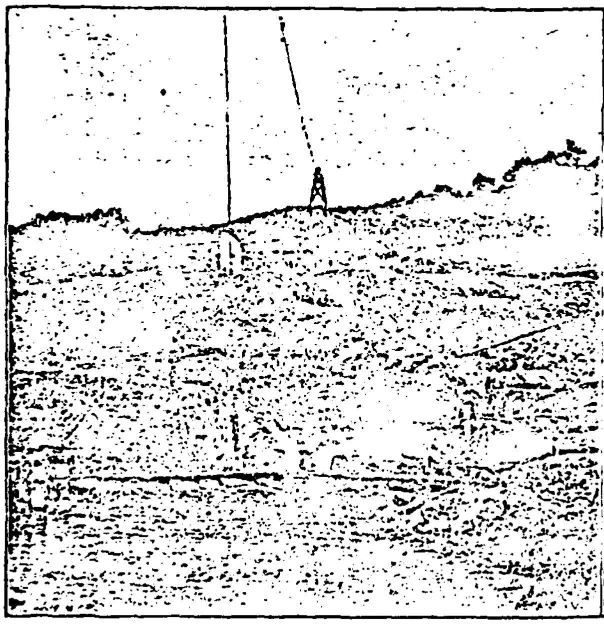
The New Gravity Water Works at Hudson, N. Y.

A storage reservoir and pipe line have just been completed at Hudson, N. Y., which furnish that city with a gravity supply from a catchment area adjoining the area at the upper end of the Roeliff Jansen Kill, on the east side of the Hudson River, which has been under consideration as a probable source of supply for New York City. Hudson is located on the east bank of the Hudson River, and the municipal water supply was formerly pumped from that stream to two open slow sand filters on a hill above the city. After passing through the filters the water flowed by gravity to a 3,200,000-gal. clear water reservoir on the same hill at an elevation of 310 ft. above the river and 175 ft. above the business portion of Hudson, and from this reservoir through the distribution system.

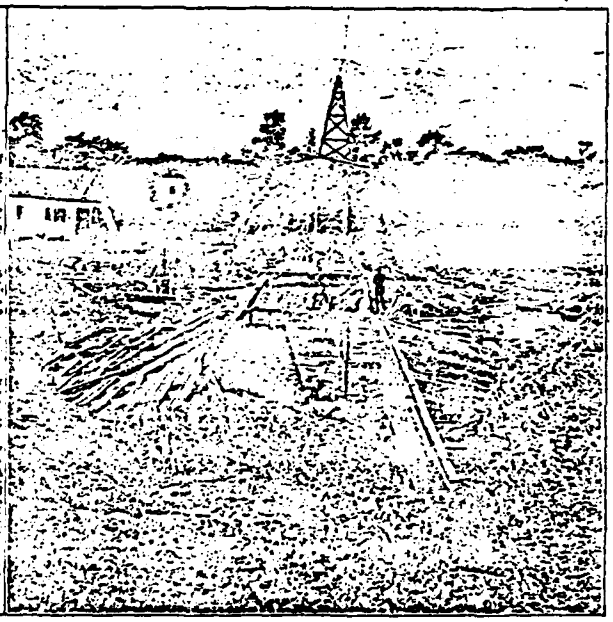
One of the filter beds and the clear water reservoir were designed and built in 1874 by Mr. J. B. G. Rand, and the second bed was built in 1888. Both beds and the clear water reservoir have concrete bottoms, with their side slopes paved with quarry-faced granite blocks laid in cement mortar. The first bed built is 330 ft. square, and the other one is irregularly rectangular, 290 ft. long by 250 ft. wide at its broad end, built to fit the available area. The combined sand area of the two beds is about 32,000 sq. ft., and their combined capacity under normal conditions of operation was formerly 1,500,000 gal. in 24 hr.

The raw river water, which is heavily charged with sediment at certain seasons of the year, was pumped directly on the filters, as a settling basin which appears to have been included in the original design was never built. Although the surface of the sand beds was scraped several times each year, the sand had never been renewed, with the result that the capacity of the beds became reduced to about 500,000 gal. in 24 hr., and their efficiency was also greatly diminished. During the winter months the heavy ice which formed on the water in the beds rendered scraping them a difficult operation, which at times became impossible. The sand would then become so clogged that in order to procure the daily supply a part of the river water would be pumped directly from the river into the reservoir. The conditions at the intake in the river also became unsanitary. The intake was about 800 ft. down-stream from the outlet in the river of one of the main sewers of the town, and 300 ft. upstream from another main sewer outlet, with a difference in level in the river of about 4 ft. between high and low tide. The river receives the sewage of Albany, Troy and several other cities before reaching the intake, and this, added to the local conditions, rendered the Hudson liable at all times to cause an epidemic of water-borne diseases.

After considerable investigation of the feasibility of constructing a new plant to filter the river water and of laying pipe lines to convey a supply from other available sources to the city, it was decided to abandon the old pumping station, erected in 1874, and to bring water from the Taughkanick Hills, which are about 13 miles from the reservoir on the hill above the city. The new supply is drawn from Claverack or Taughkanick Creek, about 15 miles from its mouth in the Hudson River. The catchment area above the intake is about 50 square miles in extent, made up of mountainous country, which is sparsely inhabited and comparatively free from liability of dangerous contamination.



Construction View at the Dam Showing Contractor's Plant.



First Lift of Forms for the Concrete of the Dam.

The new pipe line is of cast iron, and has been designed to carry 3,000,000 gal. in 24 hr. The bed and banks of the creek at the intake are solid rock, and a channel, 8 ft. wide at bottom and 5 ft. deep below the surface of the water in the creek at its normal stage, has been cut across in the bed of the creek at a slight up-stream angle. The intake is a concrete box, 6 ft. square in plan by 10 ft. deep, built in the rock of the creek bank at the lower end of the channel blasted out of the bed of the stream. The bottom of the intake is about 6 ft. below the bottom of the channel, and its side on the stream face was omitted above the channel bottom and a movable screen of vertical iron rods placed across the opening. The outlet to the pipe line is a 16-in. cast-iron pipe provided with a screen at its open end in the intake and with a gate valve just outside the intake. A 12-in. cast-iron pipe blowoff, provided with a gate valve, is placed near the bottom of the intake.

The 13-mile pipe line has two sections, first a 5-mile length, ending in a storage reservoir built in connection with the aqueduct, and, second, an 8-mile length, leading from this reservoir to the distributing reservoir which was formerly used for a clear-water basin for the filters. The first 2 miles of the line from the intake on the creek are 16-in. pipe in two weights, one about 1,250 lb. and the other about 1,460 lb. per 12-ft. length, depending on the depth of the line below the hydraulic grade line. The remainder of the first 5 miles is 12-in. pipe in two weights, one 1,030 lb. and the other 1,200 lb. per 12-ft. length. A 12-in. pipe could have been used for all of the first 5 miles, but as the grade of the pipe, as it is laid, rises about 15 ft. above the hydraulic grade line near the end of the 16-in. pipe, pipe of that size was used in the first 2 miles and a cut, 800 ft. long, with a maximum depth of 30 ft. in hardpan, was avoided.

CHURCHTOWN DAM

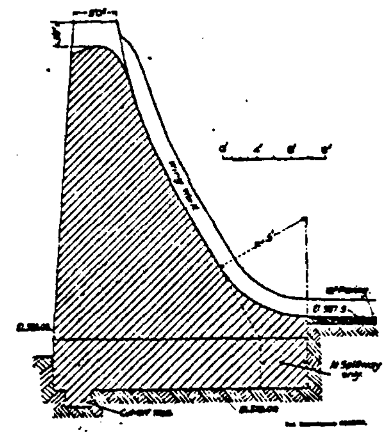
The storage reservoir in which the pipe from the intake terminates was made by building an overflow gravity-section masonry dam, 505 ft. long on the crest and 44 ft. in height near the center, across a narrow valley with steep sides. The dam develops a site which has a drainage area of 1½ square miles tributary to it, and provides an 82,000,000-gal. reservoir, covering a little less than 15 acres. The reservoir has abrupt banks on all sides, and with the exception of an area of about ¼ acre at one end, submerged only 4 ft., it will have a depth of 20 to 34 ft. The surface of the site was practically free from vegetation and organic matter, and was underlaid at a depth of a few inches with gravel, so the only preparation that was necessary was to plow the surface to a depth sufficient to turn the light top soil under the gravel. This was done over the whole area to an elevation of about 4 ft. above the flow line, and no trouble is anticipated from tastes or odors in the water due to organic matter.

Although the whole dam was designed as an overflow structure, the 40-ft. spillway built in it toward the north end is considered capable of passing any flow that may reach the reservoir. The dam is built on solid rock, which lies at a depth of from 5 ft. to 15 ft. below the original ground surface, and construction was begun by stripping the site down to this foundation. In the soundings for the dam it was thought that rock lay within 2 ft. to 4 ft. of the surface, but when the top soil was stripped, what was considered rock in the soundings was found to be a very dense hardpan, from 3 ft. to 12 ft. deep, overlying the rock ledge.

In making the excavation for the dam the top soil was first thrown back on either side by hand. A guyed derrick was then set up at the different points of the deepest cutting, and the excavated material spoiled below the site of the dam or hauled out of the trench in wagons, until a 550-ft. Lidgerwood cableway was erected longitudinally across the site. After the cableway was in place all spoil and concrete were handled in buckets on it. The small stream which formerly flowed across the site caused some trouble and had to be kept out of the trench by cofferdams on one or two occasions, but usually the work was comparatively dry.

While the excavation was in progress a stone crusher built by the Acme Road Machine Co., and a 1-yd. Ransome concrete mixer were set up adjacent to the hoisting engine and head tower of the cableway at the south end of the dam. The crusher was fitted with an elevating conveyor which delivered the broken stone to a bin over the mixer. The bin was fitted with a hopper measuring box, which discharged into the mixer. The sand and cement were also delivered on an elevated platform over the mixer built in connection with the stone bin. A 30-h.p. vertical boiler supplied steam during the first part of the work, but later a 150-h.p. horizontal boiler was placed in a brick setting near the crusher and mixer, and furnished steam for all of the contractor's plant during the greater part of the dam construction.

The dam was built in 50-ft. sections, with a tongue and groove tar joint between the sections. As soon as the rock in the foundation had been stripped it was roughly leveled, and then the trench was completely filled with concrete to a sufficient depth to bring it level. The first lift of the forms was then erected, and the construction of the dam proper begun. Alternate 50-ft. sections were built at the same time. After the first lift of the forms had been filled, a 3-ft. layer of concrete was placed in one section on one day, then permitted to set a day while a 3-ft. layer was placed in an alternate section, after which another 3-ft. layer was placed in the first section, and so on. The surface of each layer was thoroughly brushed and cleaned, then wet and covered with a thin coat of 1:2 Portland cement mortar before the next layer was placed. This method of laying the concrete was followed in order that the forms might be built without exterior braces to hold them in place, and could be kept in position



Cross Section of Dam through Spillway.

by transverse rods between the sides of the sections and by the curvature of the front face of the dam, the lower forms being removed as the concrete received its set. No leaks are apparent at any of the horizontal joints, and only a slight demarcation is apparent between any of the layers.

The concrete used in the dam was mixed quite wet in the proportion of 1 part of Hudson Portland cement, 2.8 parts sand, and 5½ parts broken stone, these proportions having been found to give a slight excess of fine material. A suitable sand was not procurable in the vicinity, so a bank was opened about 2 miles from the dam. The sand from it was found to contain from 6 to 8 per cent. of loam. Thorough tests were made to discover, if possible, the effect of the presence of the loam; as good results were obtained in these tests, the sand was used. The best stone available were the glacial bowlders which had been used in building stone fences in the vicinity, and after a considerable quantity of these had been used a quarry of trap rock was opened about ½ mile from the dam, and stone from it used in the concrete to complete the work. In the early part of the work the broken stone was screened, but the greater part of the concrete was made with crusher-run broken stone, in which the largest pieces did not exceed 2½ in. in their greatest dimension.

About 7,500 cu. yd. of concrete were required in building the dam. The actual cost of mixing and placing the concrete, including the materials obtained as described, and the cost of the forms with labor at $1.50 per day, but exclusive of the cement, was a little more than $3.63 per cubic yard. The 1.1 bbl. of cement used per cubic yard cost $1.25 at a railroad station 4 miles from the dam, and that amount was hauled to the site over a pike road for 27½ cents, making the total cost of the concrete $5.17 per cu. yd. The concrete was laid at the rate of 150 cu. yd. per day under normal conditions. Seventy-seven working days were consumed in building the forms and placing the concrete; and 146 days elapsed from the time ground was broken on the dam excavation until work on the dam was stopped on account of severely cold weather, with all but about 200 yd. of the concrete in place.

The 12-in. pipe of the line from the intake on the creek passes along the south end of the dam and the south side of the reservoir to an outlet about 6 ft. above the bottom near the upper end of the reservoir. A 6-in. branch on this pipe is laid from the dam toward the center of the reservoir where a half-bend was inserted, and the pipe built up to a point above high-water level. This branch will be used as an aerator if the water from the creek should need aeration at any time.

Water may be drawn from the reservoir through either of two 16-in. outlet pipes in the 16x18-ft. gate chamber that is built in connection with the dam. One outlet pipe has its center line 4 ft. 9 in. below the high-water level in the reservoir, and the other has its center line 21 ft. below that level. Both pipes discharge through screens in the wall of a transverse chamber in the gate chamber into an outlet chamber which is connected by an 18-in. outlet to the pipe line to the city. An 18-in. blow-off is laid through the dam beneath the gate house, and the reservoir may be drawn dry through it. All the outlet pipes are controlled by hand-operated gate valves.

The inlet to the reservoir and the outlet from it are connected by a by-pass permitting the reservoir to be entirely cut out of the system. An overflow is built in this by-pass, with its discharge at the same height as the high-water level in the reservoir, in order that the pressure on the main leading to the city may not exceed that due the head of water in the reservoir.

The 82,000,000-gal. capacity of the reservoir is about equal to 45 days' maximum consumption in the city. The normal consumption is 1,500,000 gal. per 24 hr., which is about 150 gal. per capita per day. The catchment area directly tributary to the reservoir site has given an average flow during the past two years of 1,200,000 gal. per 24 hr., with the rainfall from 3 to 6 in. below the normal, and the minimum flow to be expected from this area for any extended time is taken to be 750,000 gal. per 24-hr. The pipe line from the intake on the creek to the reservoir has been designed for a carrying capacity of 2,225,000 gal. in 24 hr., and the line from the reservoir to the city for a capacity of 3,000,000 in 24 hr. The depth of water in the reservoir, the excess of the supply over the demand and the depth below the surface at which water is fed into the reservoir are believed to produce sufficient currents and change of water to prevent any possibility of stagnation.

The pipe line from the reservoir to the city is of 16-in. cast-iron pipe in three weights, ranging from 1,350 to 1,675 lb. per 12-ft. length. No unusual difficulties were encountered in laying this part of the line nor in the line above the reservoir. The minimum depth of trench was about 5 ft., and this depth was maintained throughout the greatest part of the route. About 60 per cent. of the trench was wet, but no sheeting was required, and the water was removed with diaphragm pumps. Considerable rock cutting was required in making the trench, and two Ingersoll-Sergeant and three Rand steam drills were used in making the blast holes. Two creek crossings were made. One of them presented no difficult conditions, and the pipe was laid 3 ft. below the bed of the stream. Coarse gravel was encountered at the other crossing, and pipe with flexible joints was used to avoid pumping and building cofferdams. Air valves are placed on the pipe line at all summits and blow-off pipes at all low points.

The 4,000 tons of pipe required in building the pipe line and all of the gate and air valves and the valve boxes were furnished by R. D. Wood & Co., of Philadelphia, Pa. The contract for laying the pipe and building the dam was let to Hurd, Sherman & Co., of Syracuse, N. Y.

The saving in the operation of the gravity system as compared with the operation of the old pumping plant, is about $10,000 a year, including the salaries of three firemen and three engineers, and an average of 145 tons of coal per month. The estimated cost of rebuilding the old plant and enlarging its capacity to 3,000,000 gal. per day was $160,000, with an estimate life of the machinery in the remodeled plant of 30 years. The cost of the new works, including all charges and construction expenses will be about $270,000, with an estimated life of from 60 to 75 years.

While the average consumption of water per capita per day in Hudson is comparatively high, it will be difficult to reduce it to any considerable extent, owing to the peculiar conditions under which the water works system is operated. The original system was built under an act of the Legislature, which required that the works be built and operated with money obtained by a tax on the property in the city, and that water be furnished free for domestic consumption to any person paying the expense of installing a service connection. The system is still operated under that act, so the only direct income of the plant is the sale of a small percentage of the supply for commercial consumption, and the only opportunity of reducing the consumption under the present conditions is by metering the service connections of commercial consumers.

The filters are at present out of commission, but it is the intention to remodel them and filter the water from the gravity supply, and plans are now being prepared for the work. Mr. H. K. Bishop is chief engineer of the Hudson water works and the preliminary investigations, the design and construction of the new system have been carried out under his direct supervision. Mr. C. C. Vermeule, of New York, has been consulting engineer on the design and construction of the system. Mr. F. L. Getman was assistant engineer in charge of the laying of the pipe line, and Mr. H. W. Lewis was assistant engineer in charge of the construction of the dam.

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

PROJECT GRID

JOB	SHEET NO.	CHECKED BY	DATE
CHURCHTOWN RESV. DAM NY-79	1/		
SUBJECT		**COMPUTED BY**	**DATE**
WATERSHED PARAMETERS		WCL	12/30/80

SNYDER UNIT HYDROGRAPH :

$L = 2.01$ MILES $= 10650'$

$L_{CA} = 0.909$ MILES $= 4800'$

USE $C_t = 2.3$ ← FROM { CORPS OF ENGINEERS LOWER HUDSON RIVER BASIN HYDROLOGIC FLOOD ROUTING MODEL }

LAG TIME (HRS): $t_p = C_t (L \times L_{CA})^{0.3}$

$= 2.3 (2.01 \times 0.909)^{0.3}$

$t_p = 2.756$ HRS

UNIT RAINFALL DURATION (HRS): $t_r = \frac{t_p}{5.5}$

$t_r = \frac{2.756}{5.5}$

$t_r = 0.501$ HRS ← (USE $t_R = 0.5$ HRS)

ADJUSTED LAG TIME (HRS): $TP = t_p + 0.25 (t_R - t_r)$

$= 2.756 + 0.25 (0.5 - 0.501)$

$TP = 2.756$

PEAKING COEFFICIENT :

$640\ C_p = 340$ ← FROM SUBAREA # 11 (REF = SAME)

$CP = 0.53$

SNYDER

$TP = 2.75$ HRS $CP = 0.53$

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

PROJECT GRID

JOB	SHEET NO.	CHECKED BY	DATE
CHURCHTOWN RESV. DAM	2/		
SUBJECT		**COMPUTED BY**	**DATE**
WATERSHED PARAMETERS		WCL	12/30/80

DRAINAGE AREA:

SCALE 1:2000
1 SQ IN = 91.827 ACRES

USGS 7.5' QUAD — PLANIMETERED @ 7.44 SQ IN → 683 ACRES → 1.067 SQ.MI.

(ELEV 425) RESV. SURFACE — " @ 0.18 SQ IN → 16.5 ACRES

BASE FLOW:

INITIAL @ 1csm = 1 cfs/SQ MI
QRCSN = 3
RTIOR = 3

FROM: CORPS ENGINEERS LOWER HUDSON RIVER BASIN MODEL STUDY

LOSSES (SOIL INFILTRATION)

INITIAL = 1.0 INS.
CONSTANT = 0.05 IN/HR ← USE

REF: SOIL SURVEY OF COLUMBIA COUNTY (1929)

DUTCHESS GRAVELLY LOAM
DUTCHESS SLATE LOAM
DRAINAGE IS GOOD OR EXCESSIVE ∴ USE SCS GROUP C

SOIL RETENTION ≈ 0.1 IN/HR

RAINFALL – PMP

REF: HMR #33

ZONE 1 INDEX PMP = 20" (200 SQ MI / 24 HR)

ADJUSTMENT	DURATION →	6	12	24	48	(HRS)
FOR TIME & DA	% OF INDEX =	111	123	132	142	

[LOWER LIMIT OF CHART FOR 10 SQ MI]

00-15-1 (3/78)
Formerly GA-17

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

PROJECT GRID

JOB	SHEET NO.	CHECKED BY	DATE
CHURCHTOWN RESV. DAM	3/		
SUBJECT		COMPUTED BY	DATE
STAGE - STORAGE DATA		WCL	12/30/30

REF: ENGINEERING RECORD - 1905 (3.067 AC-FT = 10^6 GALS)

STORAGE VOL (@ SPILLCREST) = 32×10^6 GALS ⟶ 251 AC-FT ⟵

SURFACE AREA @ SPILLCREST = 15 ACRES ⟵ USE

(FROM SHT 2/) ⟶ 16.5 ACRES

FIELD MEASUREMENT - 10/80 SPILLCREST TO TOP DAM = 3.8'

ΔVOL = 15 x 3.8 = 57 AC-FT

STORAGE VOL (@ TOP DAM) = 308 AC-FT ⟵

APPROX. DEPTH TO BOTTOM OF RESV. @ UPSTREAM FACE OF DAM:

H ≈ 40' ⟶ ELEV. 388.8 ELEV. 389 VOL = 1.0 AC-FT ⟵

00-15-1 (3/78)
Formerly GA-17

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

PROJECT GRID

JOB	SHEET NO.	CHECKED BY	DATE
CHURCHTOWN RESV. DAM	4		
SUBJECT: SPILLWAY - DISCHARGES		COMPUTED BY: WCL	DATE: 12/31/80

WEIR FLOW : $Q = CLH^{3/2}$

$L = L' - 2(NK_p + K_a)H$ VARIES W/ H ABUTMENT CONTRACTION

$N = 0$

$L' = 39.6$ $K_a = 0.2$

C - VARIES W/ H USE TABLE 5-13 {KING & BRATER 5TH ED HANDBOOK OF HYDRAULICS}

8' MODEL = #5-16

$(L = L' - 0.4H)$

ELEV.	H	L	C	Q (cfs)
425	-0-	39.6'	3.10	—
	0.5	39.4	3.20	44
	1	39.2	3.30	129
	1.5	39	3.32	237
	2	38.8	3.36	368
	2.5	38.6	3.40	518
	2.8	38.48	3.42	616

H	ΔH	(L' = 43.6) L	C		+ΔQ	
3	0.2	43.52	3.3		12	= 628
3.5	0.7	43.32	3.3		83	= 699
TOP DAM 3.8	1	43.2	3.3	616	142	= 758

TOP OF DAM : $Q = CLH^{3/2}$

$C = 3.1$

$L = 382'$

DISCHARGE CAPACITY - WITH 12" FLASHBOARDS

$Q = CLH^{3/2}$ $C = 3.9$ FOR $H/P = 1.8$

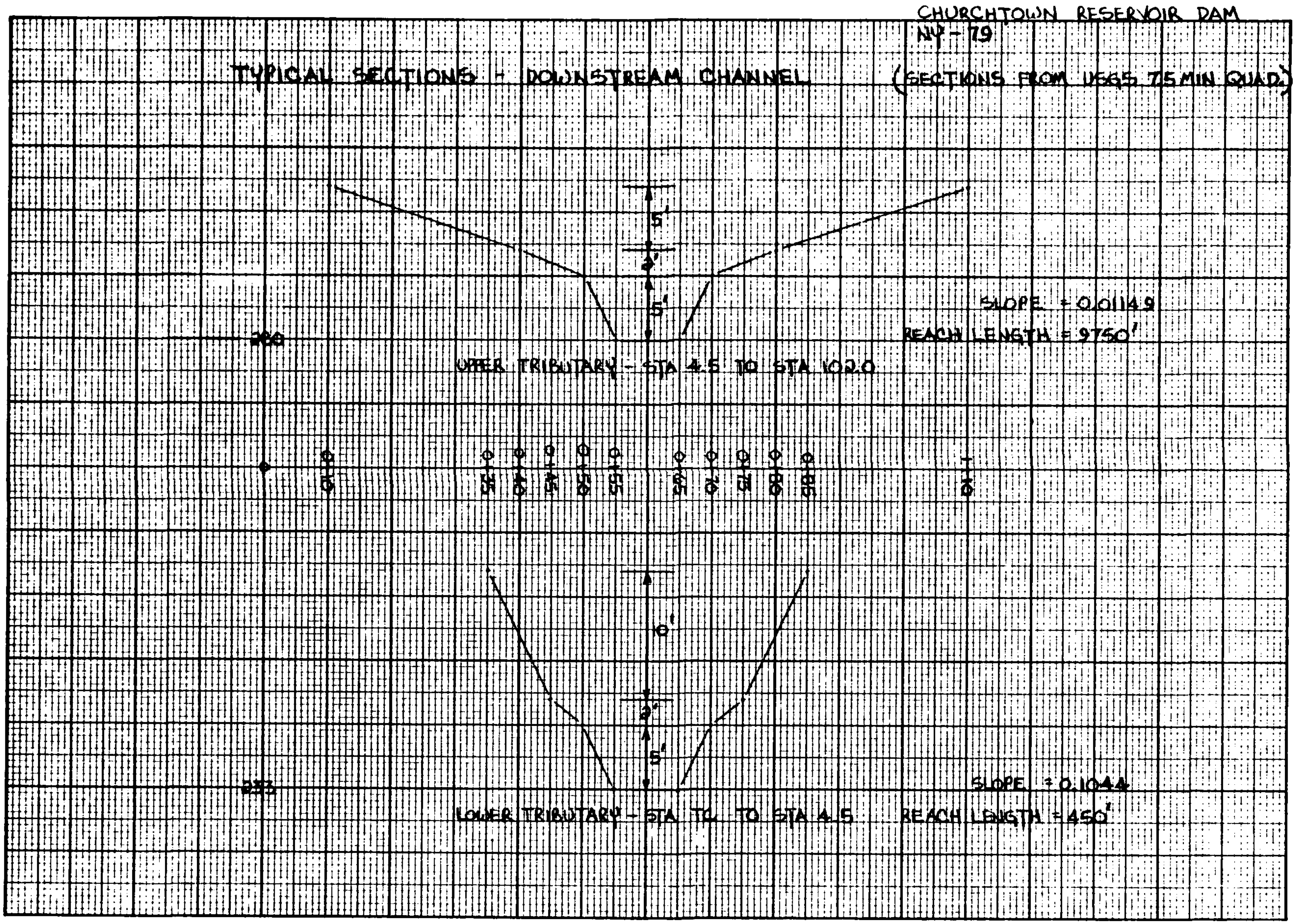
$H = 1.8 \rightarrow L = 38.9$

$Q = (3.9)(38.9)(1.8)^{1.5}$ = 366

+ 142

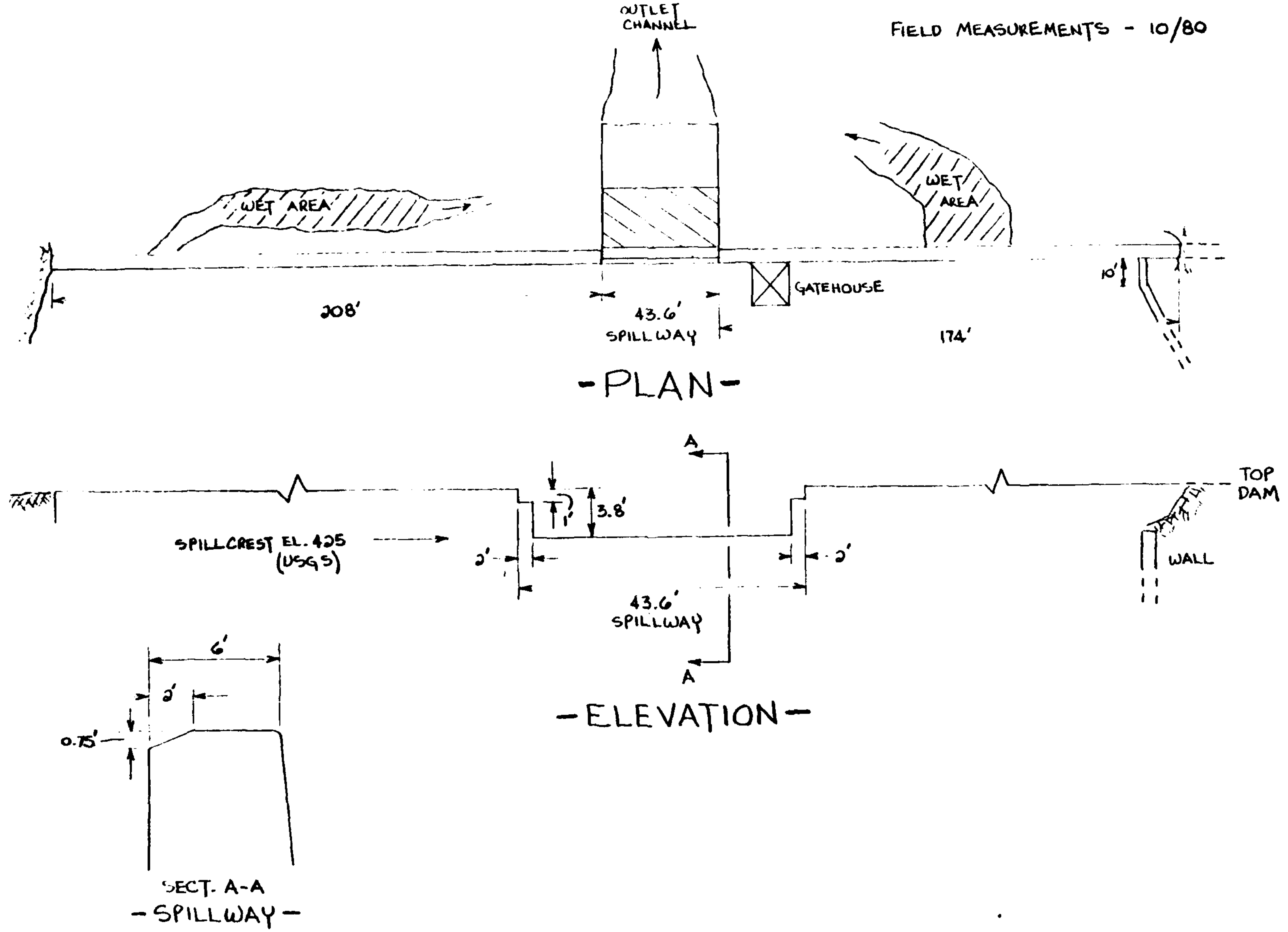
Q = 508 cfs

K•E 20 X 20 TO THE INCH 46 1240
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



CHURCHTOWN RESV. DAM
NY-79

FIELD MEASUREMENTS - 10/80

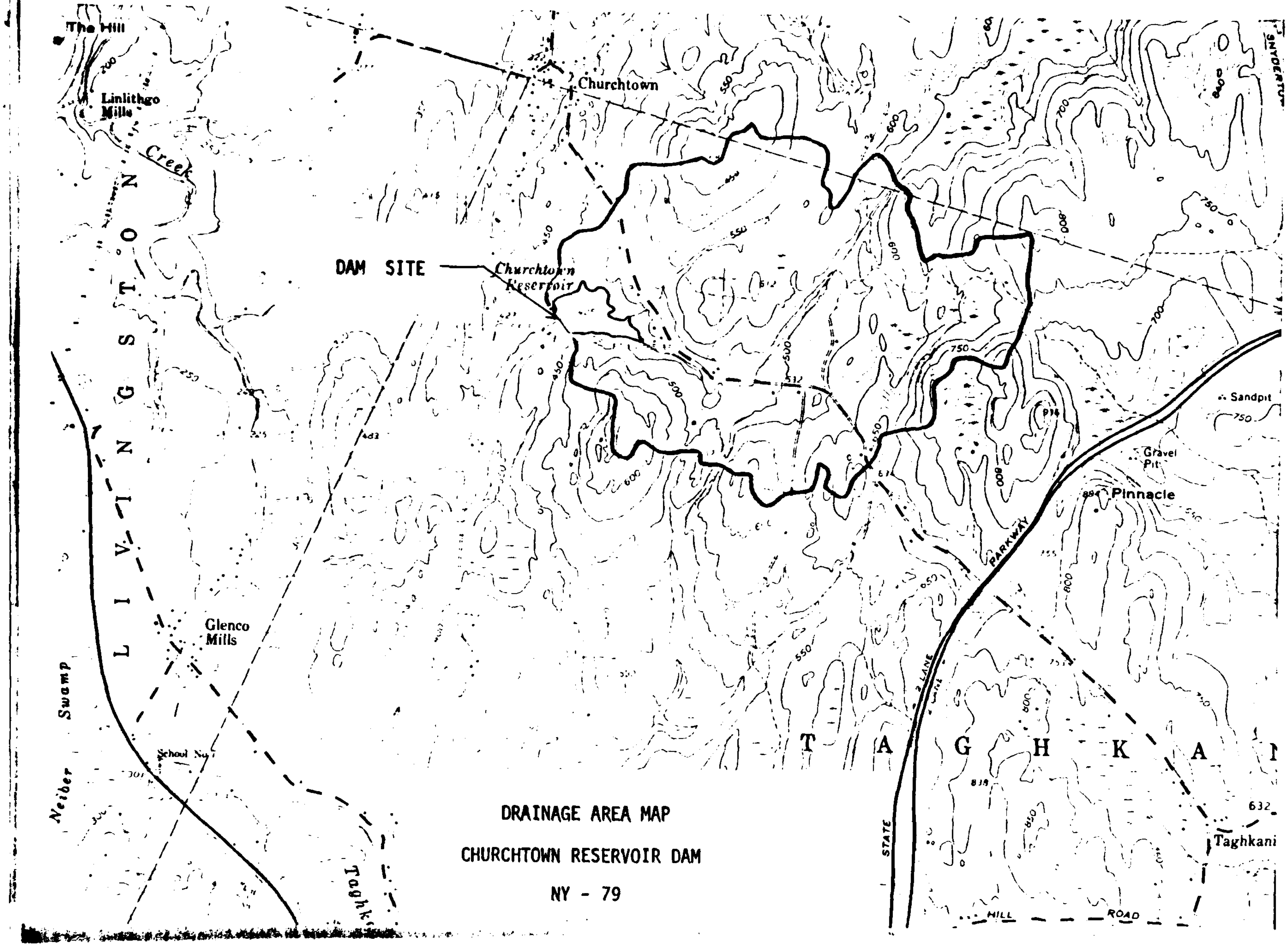


HOURLY PRECIPITATION @ RECORDING GAGE (NOAA INDEX # 1483) - CHURCHTOWN RESERVOIR (CITY OF HUDSON)

STORM EVENT : JUNE 30, 1973

DATE	AM												PM												TOTAL
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	
6/28												.10	.02												0.12
6/29						—	.60	.46	.04	—	.06	—	.01	.07	.02	.39	.16	.12	.01	.07	.01	.04	.09	.15	2.30
6/30	.07	.53	.45	1.06	.65	.05	—																		2.92

CHURCHTOWN RESERVOIR DAM
NY-79



DRAINAGE AREA MAP

CHURCHTOWN RESERVOIR DAM

NY - 79

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***********************************                                            ***********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)                                               NEW YORK STATE
DAM SAFETY VERSION      JULY 1978                                              DEPT OF ENVIRONMENTAL CONSERVATION
 LAST MODIFICATION  26 FEB 79                                                  FLOOD PROTECTION BUREAU
  MODIFIED FOR HONEYWELL APR 79
***********************************                                            ***********************************
   1           A  NY-79    CHURCHTOWN RESERVOIR DAM                   LOWER HUDSON RIVER BASIN
   2           A           DEC - 1009 LH  -- TAGHKANIC CREEK          COLUMBIA COUNTY
   3           A                                                      SNYDER LH
   4           A    150       0      30       0       0       0       0       0       0       0
   5           B1     5

   6           J      1       4       1

   7           J1  0.45    0.46    0.50       1

   8           K      0   BASIN                                       1

   9           K1             INFLOW HYDROGRAPH -- DAM

  10           M      1       1   1,067                                               1

  11           P             20     111     123     132     142

  12           T                                                    1.0    0.05            0.024

  13           W   2.75    0.53

  14           X      1       3       3

  15           K      1     DAM                                       1

  16           K1             ROUTED OUTFLOW - SPILLCREST ELEV 425 - USGS

  17           Y                              1       1

  18           Y1     1                                           -425      -1

  19           Y4   425   425.5     426   426.5     427   427.5   427.8     428   428.5   428.8

  20           Y5     0      44     129     237     368     518     616     628     699     758

  21           $S   251     308

  22           $E   425   428.8

  23           $S   425

  24           $D 428.8     3.1     1.5     382

  25           K      1   UPTRB                                       1

  26           K1             CHANNEL ROUTING OF HYDROGRAPH TO STATION 4.5

  27           Y                              1       1

  28           Y1     4

  29           Y6  0.04    0.04    0.04     280     300    9750 0.01149

  30           Y7    10     292      40     287      50     285      55     280      65     280

  31           Y7    7[illegible]     235      [illegible]     287     110     292
```

```
32   K      1  LONTRO                                          1
33   K1            CHANNEL ROUTING OF HYDROGRAPH TO STATION TC
34   Y                            1         1
35   Y1     1
36   Y6  0.04    0.04    0.04    233     280     450  0.1044
37   Y7    35     250      45    240      50     238      55     233      65     233
38   Y7    70     238      75    240      85     250
39   K     99
40   A
41   A
42   A
43   A
44   A
```

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS
         RUNOFF HYDROGRAPH AT          BASIN
         ROUTE HYDROGRAPH TO             DAM
         ROUTE HYDROGRAPH TO           UPTRB
         ROUTE HYDROGRAPH TO          LOWTRB
         END OF NETWORK
```

```
*********************************                                          *********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)                                           NEW YORK STATE
DAM SAFETY VERSION       JULY 1978                                         DEPT OF ENVIRONMENTAL CONSERVATION
  LAST MODIFICATION  26 FEB 79                                             FLOOD PROTECTION BUREAU
  MODIFIED FOR HONEYWELL APR 79
*********************************                                          *********************************

RUN  DATE 01/21/81
                NY-79      CHURCHTOWN RESERVOIR DAM                        LOWER HUDSON RIVER BASIN
                           DEC - 1009 LH  -- TAGHKANIC CREEK               COLUMBIA COUNTY
                                                                           SNYDER UH

                                            JOB SPECIFICATION
               NQ       NHR      NMIN     IDAY      IHR      IMIN    METRC     IPLT      IPRT    NSTAN
              150         0        30        0        0         0        0        0         0        0
                                         JOPER      NWT     LROPT    TRACE
                                             5        0         0        0

                                 MULTI-PLAN ANALYSES TO BE PERFORMED
                                       NPLAN= 1 NRTIO= 4 LRTIO= 1
                RTIOS=   0.45    0.46    0.50    1.00

          **********          **********          **********          **********          **********

                                        SUB-AREA RUNOFF COMPUTATION

                          INFLOW HYDROGRAPH -- DAM
                            ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                            BASIN        0        0        0        0        0        1        0        0

                                            HYDROGRAPH DATA
              IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
                  1        1     1.07      0.      1.07      0.       0.         0        1        0

                                             PRECIP DATA
                         SPFE      PMS       R6      R12      R24      R48      R72      R96
                          0.     20.00   111.00   123.00   132.00   142.00      0.       0.
TRSPC COMPUTED BY THE PROGRAM IS 0.800

                                              LOSS DATA
           LROPT    STRKR    DLTKR    RTIOL    ERAIN    STRKS    RTIOK    STRTL    CNSTL    ALSMX    RTIMP
               0      0.       0.      1.00      0.       0.      1.00     1.00     0.05      0.      0.02

                                         UNIT HYDROGRAPH DATA
                                   TP=  2.75      CP=0.53       NTA=  0

                                              RECESSION DATA
                             STRTQ=     1.00     QRCSN=     3.00     RTIOR= 3.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.99 AND R= 6.87 INTERVALS

               UNIT HYDROGRAPH 40 END-OF-PERIOD ORDINATES, LAG=   2.73 HOURS, CP= 0.53   VOL= 1.00
           9.        33.       66.      100.      124.      133.      124.      107.       92.       80.
          69.        60.       52.       45.       38.       33.       29.       25.       21.       19.
          16.        14.       12.       10.        9.        8.        7.        6.        5.        4.
           4.         3.        3.        2.        2.        2.        2.        1.        1.        1.

      0                                       END-OF-PERIOD FLOW
   MO.DA   HR.MN  PERIOD    RAIN    EXCS    LOSS    COMP Q      MO.DA  HR.MN  PERIOD    RAIN    EXCS    LOSS     COMP Q
    1.01    0.30       1    0.00    0.00    0.00        1.       1.02  14.00      76    1.07    1.04    0.02      322.
```

1.02	10.30	69	0.16	0.14	0.02	119.	1.04	0.	144	0.	0.	0.	0.
1.02	11.00	70	0.16	0.14	0.02	128.	1.04	0.30	145	0.	0.	0.	0.
1.02	11.30	71	0.16	0.14	0.02	136.	1.04	1.00	146	0.	0.	0.	0.
1.02	12.00	72	0.16	0.14	0.02	143.	1.04	1.30	147	0.	0.	0.	0.
1.02	12.30	73	0.99	0.86	0.02	155.	1.04	2.00	148	0.	0.	0.	0.
1.02	13.00	74	0.89	0.86	0.02	185.	1.04	2.30	149	0.	0.	0.	0.
1.02	13.30	75	1.07	1.04	0.02	239.	1.04	3.00	150	0.	0.	0.	0.
									SUM	22.72	20.40	2.32	27963.
										(577.)	(518.)	(59.)	(791.82)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1792.	1395.	559.	194.	27972.
CMS	51.	40.	16.	6.	792.
INCHES		12.16	19.49	20.32	20.32
MM		308.99	494.93	516.16	516.18
AC-FT		692.	1108.	1156.	1156.
THOUS CU M		853.	1367.	1426.	1426.

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	4.	9.	13.	18.	21.	23.	23.	21.
19.	17.	15.	13.	11.	9.	8.	7.	6.	6.
6.	5.	7.	8.	9.	10.	10.	11.	11.	12.
13.	15.	18.	24.	30.	37.	42.	49.	54.	58.
61.	64.	70.	83.	108.	145.	193.	250.	311.	388.
439.	605.	702.	776.	806.	787.	735.	670.	597.	523.
456.	399.	348.	305.	269.	235.	207.	182.	160.	140.
122.	105.	91.	79.	68.	59.	51.	44.	38.	33.
28.	24.	21.	17.	15.	12.	10.	8.	6.	4.
3.	2.	1.	1.	1.	1.	1.	1.	1.	1.
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	806.	628.	251.	87.	12587.
CMS	23.	18.	7.	2.	356.
INCHES		5.47	8.77	9.14	9.14
MM		139.05	222.72	232.27	232.28
AC-FT		311.	499.	520.	520.
THOUS CU M		384.	615.	642.	642.

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 2

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
1.	2.	4.	8.	13.	18.	22.	23.	23.	22.
20.	17.	15.	13.	11.	10.	8.	7.	6.	6.
6.	6.	7.	8.	9.	10.	11.	11.	12.	12.
13.	15.	19.	24.	31.	38.	44.	50.	55.	59.
63.	66.	71.	85.	110.	148.	198.	256.	318.	396.
503.	613.	718.	793.	824.	805.	751.	685.	610.	535.
467.	407.	356.	312.	274.	241.	212.	187.	164.	143.
124.	108.	93.	80.	69.	60.	52.	45.	39.	33.
29.	25.	21.	18.	15.	13.	10.	8.	7.	4.
3.	2.	1.	1.	1.	1.	1.	1.	1.	1.
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME

1.01	[illegible]	1	[illegible]	[illegible]	[illegible]	1.	1.02	[illegible]	76	1.07	[illegible]	[illegible]	3?2.
1.01	1.00	2	0.00	0.00	0.00	1.	1.02	14.30	77	1.33	1.31	0.02	429.
1.01	1.30	3	0.00	0.00	0.00	1.	1.02	15.00	78	1.33	1.31	0.02	556.
1.01	2.00	4	0.00	0.00	0.00	1.	1.02	15.30	79	1.62	1.60	0.02	690.
1.01	2.30	5	0.00	0.00	0.00	1.	1.02	16.00	80	5.13	5.10	0.02	862.
1.01	3.00	6	0.00	0.00	0.00	1.	1.02	16.30	81	1.24	1.22	0.02	1086.
1.01	3.30	7	0.00	0.00	0.00	1.	1.02	17.00	82	1.24	1.22	0.02	1333.
1.01	4.00	8	0.00	0.00	0.00	0.	1.02	17.30	83	0.98	0.95	0.02	1560.
1.01	4.30	9	0.00	0.00	0.00	0.	1.02	18.00	84	0.98	0.95	0.02	1724.
1.01	5.00	10	0.00	0.00	0.00	0.	1.02	18.30	85	0.07	0.05	0.02	1792.
1.01	5.30	11	0.00	0.00	0.00	0.	1.02	19.00	86	0.07	0.05	0.02	1749.
1.01	6.00	12	0.00	0.00	0.00	0.	1.02	19.30	87	0.07	0.05	0.02	1634.
1.01	6.30	13	0.01	0.00	0.01	0.	1.02	20.00	88	0.07	0.05	0.02	1488.
1.01	7.00	14	0.01	0.00	0.01	0.	1.02	20.30	89	0.07	0.05	0.02	1326.
1.01	7.30	15	0.01	0.00	0.01	0.	1.02	21.00	90	0.07	0.05	0.02	1163.
1.01	8.00	16	0.01	0.00	0.01	0.	1.02	21.30	91	0.07	0.05	0.02	1014.
1.01	8.30	17	0.01	0.00	0.01	0.	1.02	22.00	92	0.07	0.05	0.02	886.
1.01	9.00	18	0.01	0.00	0.01	0.	1.02	22.30	93	0.07	0.05	0.02	774.
1.01	9.30	19	0.01	0.00	0.01	0.	1.02	23.00	94	0.07	0.05	0.02	678.
1.01	10.00	20	0.01	0.00	0.01	0.	1.02	23.30	95	0.07	0.05	0.02	595.
1.01	10.30	21	0.01	0.00	0.01	0.	1.03	0.	96	0.07	0.05	0.02	523.
1.01	11.00	22	0.01	0.00	0.01	0.	1.03	0.30	97	0.	0.	0.	461.
1.01	11.30	23	0.01	0.00	0.01	0.	1.03	1.00	98	0.	0.	0.	405.
1.01	12.00	24	0.01	0.00	0.01	0.	1.03	1.30	99	0.	0.	0.	356.
1.01	12.30	25	0.07	0.00	0.07	0.	1.03	2.00	100	0.	0.	0.	311.
1.01	13.00	26	0.07	0.00	0.07	0.	1.03	2.30	101	0.	0.	0.	270.
1.01	13.30	27	0.03	0.00	0.03	1.	1.03	3.00	102	0.	0.	0.	234.
1.01	14.00	28	0.03	0.00	0.03	1.	1.03	3.30	103	0.	0.	0.	202.
1.01	14.30	29	0.10	0.00	0.10	1.	1.03	4.00	104	0.	0.	0.	175.
1.01	15.00	30	0.10	0.00	0.10	1.	1.03	4.30	105	0.	0.	0.	151.
1.01	15.30	31	0.12	0.00	0.12	1.	1.03	5.00	106	0.	0.	0.	130.
1.01	16.00	32	0.39	0.19	0.20	3.	1.03	5.30	107	0.	0.	0.	112.
1.01	16.30	33	0.09	0.07	0.02	9.	1.03	6.00	108	0.	0.	0.	97.
1.01	17.00	34	0.09	0.07	0.02	17.	1.03	6.30	109	0.	0.	0.	84.
1.01	17.30	35	0.07	0.05	0.02	28.	1.03	7.00	110	0.	0.	0.	72.
1.01	18.00	36	0.07	0.05	0.02	39.	1.03	7.30	111	0.	0.	0.	62.
1.01	18.30	37	0.01	0.00	0.01	47.	1.03	8.00	112	0.	0.	0.	54.
1.01	19.00	38	0.01	0.00	0.01	51.	1.03	8.30	113	0.	0.	0.	46.
1.01	19.30	39	0.01	0.00	0.01	50.	1.03	9.00	114	0.	0.	0.	39.
1.01	20.00	40	0.01	0.00	0.01	47.	1.03	9.30	115	0.	0.	0.	33.
1.01	20.30	41	0.01	0.00	0.01	43.	1.03	10.00	116	0.	0.	0.	27.
1.01	21.00	42	0.01	0.00	0.01	37.	1.03	10.30	117	0.	0.	0.	22.
1.01	21.30	43	0.01	0.00	0.01	32.	1.03	11.00	118	0.	0.	0.	18.
1.01	22.00	44	0.01	0.00	0.01	28.	1.03	11.30	119	0.	0.	0.	14.
1.01	22.30	45	0.01	0.00	0.01	24.	1.03	12.00	120	0.	0.	0.	8.
1.01	23.00	46	0.01	0.00	0.01	21.	1.03	12.30	121	0.	0.	0.	6.
1.01	23.30	47	0.01	0.00	0.01	18.	1.03	13.00	122	0.	0.	0.	4.
1.02	0.	48	0.01	0.00	0.01	16.	1.03	13.30	123	0.	0.	0.	3.
1.02	0.30	49	0.05	0.02	0.02	14.	1.03	14.00	124	0.	0.	0.	3.
1.02	1.00	50	0.05	0.02	0.02	13.	1.03	14.30	125	0.	0.	0.	2.
1.02	1.30	51	0.05	0.02	0.02	13.	1.03	15.00	126	0.	0.	0.	2.
1.02	2.00	52	0.05	0.02	0.02	14.	1.03	15.30	127	0.	0.	0.	2.
1.02	2.30	53	0.05	0.02	0.02	15.	1.03	16.00	128	0.	0.	0.	2.
1.02	3.00	54	0.05	0.02	0.02	18.	1.03	16.30	129	0.	0.	0.	2.
1.02	3.30	55	0.05	0.02	0.02	20.	1.03	17.00	130	0.	0.	0.	1.
1.02	4.00	56	0.05	0.02	0.02	21.	1.03	17.30	131	0.	0.	0.	1.
1.02	4.30	57	0.05	0.02	0.02	23.	1.03	18.00	132	0.	0.	0.	1.
1.02	5.00	58	0.05	0.02	0.02	24.	1.03	18.30	133	0.	0.	0.	1.
1.02	5.30	59	0.05	0.02	0.02	25.	1.03	19.00	134	0.	0.	0.	1.
1.02	6.00	60	0.05	0.02	0.02	26.	1.03	19.30	135	0.	0.	0.	1.
1.02	6.30	61	0.16	0.14	0.02	28.	1.03	20.00	136	0.	0.	0.	1.
1.02	7.00	62	0.16	0.14	0.02	33.	1.03	20.30	137	0.	0.	0.	1.
1.02	7.30	63	0.16	0.14	0.02	41.	1.03	21.00	138	0.	0.	0.	1.
1.02	8.00	64	0.16	0.14	0.02	52.	1.03	21.30	139	0.	0.	0.	1.
1.02	8.30	65	0.16	0.14	0.02	67.	1.03	22.00	140	0.	0.	0.	0.
							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.

[illegible]	23.	40.	7.	3.	384.
INCHES		5.60	8.96	9.35	9.35
MM		142.14	227.67	237.43	237.44
AC-FT		318.	510.	532.	532.
THOUS CU M		393.	629.	656.	656.

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 3

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
1.	2.	4.	9.	14.	19.	24.	25.	25.	24.
21.	19.	16.	14.	12.	10.	9.	8.	7.	6.
6.	7.	8.	9.	10.	11.	11.	12.	13.	13.
14.	16.	20.	26.	33.	41.	48.	54.	60.	64.
68.	71.	78.	92.	117.	161.	215.	278.	345.	431.
543.	667.	780.	862.	895.	875.	817.	744.	663.	582.
507.	443.	387.	337.	298.	262.	230.	203.	178.	156.
135.	117.	101.	87.	75.	65.	56.	49.	42.	36.
31.	27.	23.	19.	16.	14.	11.	9.	7.	4.
3.	2.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	896.	698.	279.	97.	13986.
CMS	25.	20.	8.	3.	396.
INCHES		6.08	9.74	10.16	10.16
MM		154.49	247.47	258.08	258.09
AC-FT		346.	554.	578.	578.
THOUS CU M		427.	684.	713.	713.

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 4

1.	1.	1.	1.	1.	1.	1.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	1.	1.	1.	1.
1.	3.	9.	17.	28.	39.	47.	51.	50.	47.
43.	37.	32.	23.	24.	21.	18.	16.	14.	13.
13.	14.	15.	18.	20.	21.	23.	24.	25.	26.
28.	33.	41.	52.	67.	82.	96.	108.	119.	128.
136.	143.	155.	185.	239.	322.	429.	556.	690.	862.
1086.	1333.	1560.	1724.	1792.	1749.	1634.	1488.	1326.	1163.
1014.	886.	774.	678.	595.	523.	461.	405.	356.	311.
270.	234.	202.	175.	151.	130.	112.	97.	84.	72.
62.	54.	46.	39.	33.	27.	22.	18.	14.	8.
6.	4.	3.	3.	2.	2.	2.	2.	2.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1792.	1395.	559.	194.	27972.
CMS	51.	40.	16.	6.	792.
INCHES		12.16	19.49	20.32	20.32
MM		308.99	494.93	516.16	516.18
AC-FT		692.	1108.	1156.	1156.
THOUS CU M		853.	1367.	1426.	1426.

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HYDROGRAPH ROUTING

1 0 C 1 0 0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.	0.	0.	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.	0.	0.	-425.	-1

STAGE	425.00	425.50	426.00	426.50	427.00	427.50	427.80	428.00	428.50	428.80
FLOW	0.	44.00	129.00	237.00	368.00	518.00	616.00	628.00	699.00	738.00

CAPACITY= 251. 308.

ELEVATION= 425. 429.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
425.0	0.	0.	0.	0.	0.	0.	0.

DAM DATA

TOPEL	COQD	EXPD	DAMWID
428.8	3.1	1.5	382.

STATION DAM, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	1.	2.	4.	6.	9.	12.	14.	16.
17.	17.	17.	16.	15.	14.	13.	12.	11.	10.
9.	8.	8.	8.	8.	8.	9.	9.	9.	10.
10.	11.	12.	14.	17.	20.	25.	29.	34.	39.
43.	50.	56.	64.	76.	95.	123.	167.	219.	285.
366.	470.	560.	635.	686.	729.	743.	726.	689.	647.
603.	496.	424.	367.	324.	286.	252.	224.	200.	177.
156.	136.	121.	107.	94.	83.	72.	63.	54.	47.
42.	39.	35.	32.	28.	25.	22.	19.	17.	14.
12.	10.	8.	7.	5.	4.	4.	3.	3.	2.
2.	2.	1.	1.	1.	1.	1.	1.	1.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORAGE

251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	252.	252.	253.	253.	253.	254.
254.	254.	254.	254.	254.	253.	253.	253.	253.	253.
253.	252.	252.	252.	252.	252.	252.	253.	253.	253.
253.	253.	253.	253.	254.	254.	255.	256.	257.	258.
258.	259.	260.	260.	261.	263.	265.	269.	272.	276.
281.	286.	291.	297.	302.	306.	307.	306.	302.	298.
292.	287.	284.	281.	279.	276.	274.	273.	271.	269.
268.	267.	265.	264.	263.	262.	261.	260.	259.	259.
258.	258.	257.	256.	256.	255.	255.	254.	254.	253.
253.	253.	252.	252.	252.	252.	252.	252.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.

STAGE

425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0

425.2	425.2	425.2	425.2	425.2	425.2	425.1	425.1	425.1	425.1
425.1	425.1	425.1	425.1	425.1	425.1	425.1	425.1	425.1	425.1
425.1	425.1	425.1	425.2	425.2	425.2	425.3	425.3	425.4	425.4
425.5	425.5	425.6	425.6	425.7	425.9	426.0	426.2	426.4	426.7
427.0	427.3	427.7	428.1	428.4	428.7	428.7	428.6	428.4	428.1
427.8	427.5	427.2	427.0	426.8	426.7	426.6	426.4	426.3	426.2
426.1	426.0	426.0	425.9	425.8	425.7	425.7	425.6	425.6	425.5
425.5	425.4	425.4	425.4	425.3	425.3	425.3	425.2	425.2	425.2
425.1	425.1	425.1	425.1	425.1	425.1	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0

PEAK OUTFLOW IS 743. AT TIME 43.50 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	743.	617.	250.	87.	12580.
CMS	21.	17.	7.	2.	356.
INCHES		5.38	8.73	9.14	9.15
MM		136.55	221.65	232.28	232.29
AC-FT		306.	496.	520.	520.
THOUS CU M		377.	612.	642.	642.

STATION DAM, PLAN 1, RATIO 2

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.	1.	2.	4.	6.	9.	12.	15.	16.
17.	17.	17.	16.	15.	14.	13.	12.	11.	10.
9.	8.	8.	8.	8.	8.	9.	9.	10.	10.
11.	11.	13.	14.	17.	21.	25.	30.	35.	39.
44.	52.	58.	66.	79.	97.	126.	171.	224.	293.
376.	431.	593.	643.	697.	747.	761.	742.	702.	659.
618.	513.	436.	377.	331.	292.	257.	228.	204.	181.
159.	139.	123.	109.	96.	84.	73.	64.	55.	48.
43.	39.	36.	32.	29.	26.	23.	20.	17.	15.
12.	10.	8.	7.	5.	5.	4.	3.	3.	2.
2.	2.	1.	1.	1.	1.	1.	1.	1.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORAGE

251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	252.	252.	253.	253.	253.	254.
254.	254.	254.	254.	254.	253.	253.	253.	253.	253.
253.	252.	252.	252.	252.	252.	252.	253.	253.	253.
253.	253.	253.	253.	254.	255.	255.	256.	257.	258.
259.	259.	260.	260.	261.	263.	266.	269.	273.	277.
281.	287.	292.	298.	303.	307.	308.	307.	304.	299.
294.	289.	284.	281.	279.	277.	275.	273.	271.	270.
269.	267.	265.	264.	263.	262.	261.	260.	260.	259.
258.	258.	257.	256.	255.	255.	255.	254.	254.	253.
253.	253.	252.	252.	252.	252.	252.	252.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.

STAGE

425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0

[illegible]	[illegible]	[illegible]	425.2	425.2	425.2	425.2	425.1	425.1	425.1
425.1	425.1	425.1	425.1	425.1	425.1	425.1	425.1	425.1	425.1
425.1	425.1	425.1	425.2	425.2	425.2	425.3	425.3	425.4	425.4
425.5	425.5	425.6	425.6	425.7	425.8	426.0	426.2	426.4	426.7
427.0	427.4	427.7	428.1	428.5	428.7	428.8	428.7	428.5	428.2
427.3	427.3	427.2	427.0	426.9	426.7	426.6	426.5	426.3	426.2
426.1	426.0	426.0	425.9	425.8	425.7	425.7	425.6	425.6	425.5
425.5	425.4	425.4	425.4	425.3	425.3	425.3	425.2	425.2	425.2
425.1	425.1	425.1	425.1	425.1	425.1	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0

PEAK OUTFLOW IS 761. AT TIME 43.50 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	761.	630.	256.	89.	12868.
CMS	22.	18.	7.	3.	364.
INCHES		5.49	8.92	9.35	9.35
MM		139.56	226.60	237.44	237.46
AC-FT		313.	507.	532.	532.
THOUS CU M		385.	626.	656.	656.

STATION DAM, PLAN 1, RATIO 3

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	1.	1.	2.	4.	7.	10.	13.	16.	18.
19.	19.	19.	18.	17.	16.	14.	13.	12.	11.
10.	9.	9.	9.	9.	9.	10.	10.	10.	11.
12.	12.	14.	16.	19.	23.	27.	32.	38.	43.
51.	58.	64.	72.	85.	106.	139.	188.	246.	321.
413.	526.	624.	684.	765.	807.	841.	780.	738.	691.
643.	589.	483.	413.	359.	317.	279.	246.	219.	195.
172.	151.	132.	117.	104.	91.	80.	69.	60.	52.
45.	41.	38.	34.	31.	27.	24.	21.	18.	16.
13.	11.	9.	7.	6.	5.	4.	3.	3.	2.
2.	2.	1.	1.	1.	1.	1.	1.	1.	1.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STORAGE

251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	252.	252.	253.	253.	254.	254.
254.	254.	254.	254.	254.	254.	253.	253.	253.	253.
253.	253.	252.	252.	252.	253.	253.	253.	253.	253.
253.	253.	253.	254.	254.	255.	256.	257.	257.	258.
259.	260.	260.	261.	262.	264.	267.	270.	274.	278.
283.	289.	295.	302.	308.	311.	310.	309.	306.	303.
298.	292.	287.	283.	280.	278.	276.	274.	272.	271.
269.	269.	266.	265.	264.	263.	262.	261.	260.	259.
257.	257.	257.	257.	256.	256.	255.	255.	254.	254.
253.	253.	252.	252.	252.	252.	252.	252.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.

STAGE

425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	425.1	425.1	425.2	425.2
425.2	425.2	425.2	425.2	425.2	425.2	425.2	425.1	425.1	425.1
425.1	425.1	425.1	425.1	425.1	425.1	425.1	425.1	425.1	425.1
425.1	425.1	425.2	425.2	425.2	425.3	425.3	425.4	425.4	425.5
425.5	425.5	425.6	425.7	425.7	425.7	426.0	426.3	426.5	426.8
427.2	427.5	427.9	428.4	428.8	429.0	428.9	428.8	428.7	428.4
428.1	427.7	427.4	427.1	427.0	426.8	426.7	426.5	426.4	426.3
426.2	426.1	426.0	425.9	425.9	425.8	425.7	425.6	425.6	425.5
425.5	425.5	425.4	425.4	425.3	425.3	425.3	425.2	425.2	425.2
425.1	425.1	425.1	425.1	425.1	425.1	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0

PEAK OUTFLOW IS 887. AT TIME 43.00 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	887.	695.	278.	97.	13987.
CMS	25.	19.	8.	3.	396.
INCHES		5.97	9.70	10.16	10.16
MM		151.60	246.35	258.09	258.10
AC-FT		339.	552.	578.	578.
THOUS CU M		419.	680.	713.	713.

STATION DAM, PLAN 1, RATIO 4

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	1.	1.	1.	1.	1.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
1.	1.	2.	4.	8.	14.	20.	26.	32.	35.
37.	39.	37.	36.	34.	31.	29.	26.	24.	21.
20.	18.	17.	17.	13.	18.	19.	20.	21.	22.
23.	25.	27.	31.	37.	47.	63.	78.	91.	104.
114.	124.	134.	151.	179.	225.	303.	407.	534.	638.
765.	1296.	1502.	1693.	1783.	1766.	1660.	1521.	1365.	1204.
1056.	927.	819.	748.	700.	654.	614.	503.	431.	374.
327.	283.	251.	220.	194.	169.	147.	128.	114.	100.
89.	77.	66.	57.	49.	43.	39.	35.	31.	27.
23.	19.	15.	13.	11.	9.	7.	6.	5.	4.
4.	3.	3.	2.	2.	2.	1.	1.	1.	1.
1.	1.	1.	1.	1.	0.	0.	0.	0.	0.

STORAGE

251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	252.	252.	253.	254.	255.	256.	257.
257.	257.	257.	257.	257.	256.	256.	255.	255.	255.
254.	254.	254.	254.	254.	254.	254.	254.	255.	255.
255.	255.	256.	256.	257.	259.	260.	261.	263.	264.
265.	266.	266.	268.	269.	273.	277.	283.	289.	297.
308.	316.	318.	319.	320.	320.	319.	318.	316.	315.
313.	311.	310.	307.	304.	299.	293.	288.	284.	281.
279.	276.	274.	272.	271.	269.	267.	266.	265.	263.
262.	261.	260.	260.	259.	258.	258.	257.	256.	256.
255.	254.	254.	253.	253.	252.	252.	252.	252.	252.
252.	252.	251.	251.	251.	251.	251.	251.	251.	251.
251.	251.	251.	251.	251.	251.	251.	251.	251.	251.

STAGE

425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0

[illegible]	[illegible]	[illegible]	[illegible]	4[illegible].4	[illegible].4	425.3	425.3	425.3	425.2
425.2	[illegible]	[illegible].2	425.2	425.2	425.2	425.2	425.2	425.2	425.3
425.3	425.3	425.3	425.4	425.4	425.5	425.6	425.7	425.8	425.9
425.9	426.0	426.0	426.1	426.2	426.4	426.8	427.1	427.5	428.1
428.8	429.1	429.4	429.6	429.6	429.6	429.5	429.5	429.4	429.3
429.1	429.0	428.9	428.7	428.5	428.2	427.8	427.4	427.2	427.0
426.9	426.7	426.6	426.4	426.3	426.2	426.1	426.0	425.9	425.8
425.8	425.7	425.6	425.6	425.5	425.5	425.4	425.4	425.4	425.3
425.3	425.2	425.2	425.1	425.1	425.1	425.1	425.1	425.1	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0
425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0	425.0

PEAK OUTFLOW IS 1783. AT TIME 42.50 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1783.	1301.	557.	194.	27973.
CMS	50.	39.	16.	6.	792.
INCHES		12.04	19.44	20.32	20.32
MM		305.77	493.74	516.17	516.20
AC-FT		685.	1106.	1156.	1156.
THOUS CU M		845.	1364.	1426.	1426.

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HYDROGRAPH ROUTING

CHANNEL ROUTING OF HYDROGRAPH TO STATION 4,5

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
UPTR6	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP		LSTR
0.	0.	0.	1	1	0	0		0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
4	0	0	0.	0.	0.	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
0.0400	0.0400	0.0400	280.0	300.0	9750.	0.01149

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
10.00 292.00 40.00 287.00 50.00 285.00 55.00 280.00 65.00 280.00
70.00 285.00 80.00 287.00 110.00 292.00

STORAGE	0.	2.60	5.70	9.30	13.39	18.04	24.62	33.70	45.65	60.58
	78.49	99.37	122.69	146.25	169.82	193.38	216.94	240.50	264.06	287.62
OUTFLOW	0.	43.19	139.05	280.20	466.78	714.24	1078.33	1564.02	2209.96	3056.10
	4134.38	5474.21	7252.52	9415.60	11843.25	14520.52	17435.43	20578.10	23940.15	27514.35
STAGE	280.00	281.05	282.11	283.16	284.21	285.26	286.32	287.37	288.42	289.47
	290.53	291.58	292.63	293.68	294.74	295.79	296.84	297.89	298.95	300.00
FLOW	0.	43.19	139.05	280.20	466.78	714.24	1078.33	1564.02	2209.96	3056.10
	4134.38	5474.21	7252.52	9415.60	11843.25	14520.52	17435.43	20578.10	23940.15	27514.35

STATION UPTR4, PLAN 1, RTIO 1

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HYDROGRAPH ROUTING

CHANNEL ROUTING OF HYDROGRAPH TO STATION TC

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
LOWTRB	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.	0.	0.	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.	0.	0.	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
0.0400	0.0400	0.0400	233.0	280.0	450.	0.10440

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

35.00 250.00 45.00 240.00 50.00 238.00 55.00 233.00 65.00 233.00
70.00 238.00 75.00 240.00 85.00 250.00

STORAGE	0.	0.32	0.76	1.42	2.23	3.25	4.36	5.59	6.86	8.14
	9.42	10.70	11.98	13.25	14.53	15.81	17.09	18.36	19.64	20.92
OUTFLOW	0.	552.67	1885.02	4604.20	8779.72	14357.98	21391.36	30068.92	41141.72	53725.20
	67726.37	83072.57	99704.63	117572.85	136634.64	156852.83	178194.58	200630.54	224134.25	248681.67
STAGE	233.00	235.47	237.95	240.42	242.89	245.37	247.84	250.32	252.79	255.26
	257.74	260.21	262.68	265.16	267.63	270.11	272.58	275.05	277.53	280.00
FLOW	0.	552.67	1885.02	4604.20	8779.72	14357.98	21391.36	30068.92	41141.72	53725.20
	67726.37	83072.57	99704.63	117572.85	136634.64	156852.83	178194.58	200630.54	224134.25	248681.67

STATION LOWTRB, PLAN 1, RTIO 1

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	1.	2.	3.	5.	8.	10.	13.
15.	16.	17.	17.	16.	16.	15.	13.	12.	11.
10.	9.	9.	8.	8.	8.	8.	8.	9.	9.
10.	10.	11.	12.	13.	16.	19.	23.	27.	32.
36.	42.	51.	58.	66.	80.	101.	133.	185.	244.
319.	413.	525.	613.	662.	709.	741.	736.	707.	667.
623.	553.	457.	395.	349.	305.	272.	241.	214.	151.
169.	148.	132.	119.	105.	92.	81.	70.	61.	53.
46.	42.	40.	37.	34.	30.	27.	24.	21.	18.
16.	13.	11.	9.	7.	6.	5.	4.	3.	3.
2.	2.	2.	1.	1.	1.	1.	1.	1.	1.
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STOR

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

CHURCHTOWN
RESERVOIR
DAM

OPERATION	STATION	AREA	PLAN	RATIO 1 0.45	RATIO 2 0.46	RATIO 3 0.50	RATIO 4 1.00
				RATIOS APPLIED TO FLOWS			
HYDROGRAPH AT	BASIN	1.07	1	806.	824.	896.	1792.
	(	-0.00)	(	22.83)(	23.34)(	25.37)(	50.74)(
ROUTED TO	DAM	1.07	1	743.	761.	887.	1783.
		(0.12E 25)	(	21.04)(	21.55)(	25.10)(	50.49)(
ROUTED TO	UPTRB	1.07	1	742.	761.	880.	1800.
	(	-0.00)	(	21.01)(	21.54)(	24.93)(	50.97)(
ROUTED TO	LOWTRB	1.07	1	741.	760.	880.	1800.
	(	-0.00)	(	20.99)(	21.52)(	24.91)(	50.97)(

SUMMARY OF DAM SAFETY ANALYSIS

CHURCHTOWN RESERVOIR DAM

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	425.00	425.00	428.80
STORAGE	251.	251.	308.
OUTFLOW	0.	0.	758.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.45	423.72	0.	307.	743.	0.	43.50	0.
0.46	428.81	0.01	308.	761.	0.50	43.50	0.
0.50	428.93	0.13	311.	887.	2.00	43.00	0.
1.00	429.61	0.81	320.	1783.	6.50	42.50	0.

PLAN 1 STATION UPTRB

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.45	742.	285.3	43.50
0.46	761.	285.4	43.50
0.50	880.	285.7	43.50
1.00	1800.	287.8	43.00

PLAN 1 STATION LOWTRB

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.45	741.	235.8	43.50
0.46	760.	235.9	43.50
0.50	880.	236.1	43.50
1.00	1800.	237.8	43.00

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********************************                                            ********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)                                            NEW YORK STATE
DAM SAFETY VERSION     JULY 1978                                            DEPT OF ENVIRONMENTAL CONSERVATION
  LAST MODIFICATION  26 FEB 79                                              FLOOD PROTECTION BUREAU
  MODIFIED FOR HONEYWELL APR 79
********************************                                            ********************************
A    NY-79     CHURCHTOWN RESERVOIR DAM                          LOWER HUDSON RIVER BASIN
A              DEC - 1009 LH  -- TAGHKANIC CREEK                 COLUMBIA COUNTY
A                                                                SNYDER LH
B      150       0      30       0       0       0       0       0       0       0
B1       5
J        1       4       1
J1    0.45    0.46    0.50       1
K        0   BASIN                                       1
K1             INFLOW HYDROGRAPH -- DAM
M        1       1   1.067                                                       1
P               20     111     123     132     142
T                                                      1.0    0.05            0.024
W     2.75    0.53
X        1       3       3
K        1     DAM                                       1
K1             ROUTED OUTFLOW - SPILLCREST ELEV 425 - USGS  -  WITH BREACH
Y                                1       1
Y1       1                                            -425      -1
Y4     425   425.5     426   426.5     427   427.5   427.8     428   428.5   428.8
Y5       0      44     129     237     368     518     616     628     699     758
$S       1     251     308
$E     389     425   428.8
$S     425
$D   428.8     3.1     1.5     382
$B      44       0     400     0.5     425   428.8
K        1   UPTRB                                       1
K1             CHANNEL ROUTING OF   BREACH   TO STATION 4.5
Y                                1       1
Y1       4
Y6    0.04    0.04    0.04     280     300    9750 0.01149
Y7      10     292      40     287      50     285      55     280      65     280
```

```
33    K      1  LOWTRB                                          1
34    K1            CHANNEL ROUTING OF    BREACH   TO STATICN TC
35    Y                                  1        1
36    Y1     1
37    Y6  0.04    0.04    0.04      233      280      450  0.1C44
38    Y7    35     250      45      240       50      238      55      233      65      233
39    Y7    70     238      75      240       85      250
40    K     99
41    A
42    A
43    A
44    A
45    A
```

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PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS
         RUNOFF HYDROGRAPH AT        BASIN
         ROUTE HYDROGRAPH TO           DAM
         ROUTE HYDROGRAPH TO         UPTRB
         ROUTE HYDROGRAPH TO        LOWTRB
         END OF NETWORK
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*********************************                                       *********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)                                         NEW YORK STATE
DAM SAFETY VERSION      JULY 1978                                        DEPT OF ENVIRONMENTAL CONSERVATION
  LAST MODIFICATION  26 FEB 79                                           FLOOD PROTECTION BUREAU
  MODIFIED FOR HONEYWELL APR 79
*********************************                                       *********************************

RUN  DATE 02/24/81
                    NY-79     CHURCHTOWN RESERVOIR DAM                        LOWER HUDSON RIVER BASIN
                              DEC - 1009 LH  -- TAGHKANIC CREEK               COLUMBIA COUNTY
                                                                              SNYDER UH

                                              JOB SPECIFICATION
                   NC      NHR     NMIN     IDAY      IHR     IMIN    METRC     IPLT     IPRT   NSTAN
                  150        0       30        0        0        0        0        0        0       0
                                            JOPER      NWT    LROPT    TRACE
                                                5        0        0        0

                                      MULTI-PLAN ANALYSES TO BE PERFORMED
                                         NPLAN= 1 NRTIO= 4 LRTIO= 1
                     RTIOS=   0.45    0.46    0.50    1.00


              *********          *********          *********          *********          *********

                                         SUB-AREA RUNOFF COMPUTATION

                              INFLOW HYDROGRAPH -- DAM
                                ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE   IAUTO
                                BASIN        0        0                 0        0        1        0       0

                                              HYDROGRAPH DATA
                   IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
                       1        1     1.07       0.     1.07       0.       0.        0        1        0

                                                PRECIP DATA
                             SPFE      PMS       R6      R12      R24      R48      R72      R96
                               0.    20.00   111.00   123.00   132.00   142.00       0.       0.
TRSPC COMPUTED BY THE PROGRAM IS 0.800

                                                 LOSS DATA
               LROPT    STRKR    DLTKR    RTIOL    ERAIN    STRKS    RTIOK    STRTL    CNSTL    ALSMX    RTIMP
                   0       0.       0.     1.00       0.       0.     1.00     1.00     0.05       0.     0.02

                                           UNIT HYDROGRAPH DATA
                                    TP=  2.75     CP=0.53     NTA=  0

                                              RECESSION DATA
                                 STRTQ=     1.00     QRCSN=     3.00     RTIOR= 3.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.99 AND R= 6.87 INTERVALS

               UNIT HYDROGRAPH 40 END-OF-PERIOD ORDINATES, LAG=  2.73 HOURS, CP= 0.53  VOL= 1.00
                    9.       33.       66.      100.      124.      133.      124.      107.       92.       80.
                   69.       60.       52.       45.       38.       33.       29.       25.       21.       19.
                   16.       14.       12.       10.        9.        8.        7.        6.        5.        4.
                    4.        3.        3.        2.        2.        2.        2.        1.        1.        1.

          0                                         END-OF-PERIOD FLOW
       MO.DA   HR.MN   PERIOD    RAIN    EXCS    LOSS    COMP Q      MO.DA   HR.MN   PERIOD    RAIN    EXCS    LCSS     COMP Q
        1.01    0.30        1    0.00    0.00    0.00        1.       1.02   14.00       76    1.07    1.04    0.02       322.
        1.01    1.00        2    0.00    0.00    0.00        1.       1.02   14.30       77    1.33    1.31    0.02       429.
```

[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	1.
1.01	2.30	5	0.00	0.00	0.00	1.
1.01	3.00	6	0.00	0.00	0.00	1.
1.01	3.30	7	0.00	0.00	0.00	1.
1.01	4.00	8	0.00	0.00	0.00	0.
1.01	4.30	9	0.00	0.00	0.00	0.
1.01	5.00	10	0.00	0.00	0.00	0.
1.01	5.30	11	0.00	0.00	0.00	0.
1.01	6.00	12	0.00	0.00	0.00	0.
1.01	6.30	13	0.01	0.00	0.01	0.
1.01	7.00	14	0.01	0.00	0.01	0.
1.01	7.30	15	0.01	0.00	0.01	0.
1.01	8.00	16	0.01	0.00	0.01	0.
1.01	8.30	17	0.01	0.00	0.01	0.
1.01	9.00	18	0.01	0.00	0.01	0.
1.01	9.30	19	0.01	0.00	0.01	0.
1.01	10.00	20	0.01	0.00	0.01	0.
1.01	10.30	21	0.01	0.00	0.01	0.
1.01	11.00	22	0.01	0.00	0.01	0.
1.01	11.30	23	0.01	0.00	0.01	0.
1.01	12.00	24	0.01	0.00	0.01	0.
1.01	12.30	25	0.07	0.00	0.07	0.
1.01	13.00	26	0.07	0.00	0.07	0.
1.01	13.30	27	0.08	0.00	0.08	1.
1.01	14.00	28	0.08	0.00	0.08	1.
1.01	14.30	29	0.10	0.00	0.10	1.
1.01	15.00	30	0.10	0.00	0.10	1.
1.01	15.30	31	0.12	0.00	0.12	1.
1.01	16.00	32	0.39	0.19	0.20	3.
1.01	16.30	33	0.09	0.07	0.02	9.
1.01	17.00	34	0.09	0.07	0.02	17.
1.01	17.30	35	0.07	0.05	0.02	28.
1.01	18.00	36	0.07	0.05	0.02	39.
1.01	18.30	37	0.01	0.00	0.01	47.
1.01	19.00	38	0.01	0.00	0.01	51.
1.01	19.30	39	0.01	0.00	0.01	50.
1.01	20.00	40	0.01	0.00	0.01	47.
1.01	20.30	41	0.01	0.00	0.01	43.
1.01	21.00	42	0.01	0.00	0.01	37.
1.01	21.30	43	0.01	0.00	0.01	32.
1.01	22.00	44	0.01	0.00	0.01	28.
1.01	22.30	45	0.01	0.00	0.01	24.
1.01	23.00	46	0.01	0.00	0.01	21.
1.01	23.30	47	0.01	0.00	0.01	18.
1.02	0.	48	0.01	0.00	0.01	16.
1.02	0.30	49	0.05	0.02	0.02	14.
1.02	1.00	50	0.05	0.02	0.02	13.
1.02	1.30	51	0.05	0.02	0.02	13.
1.02	2.00	52	0.05	0.02	0.02	14.
1.02	2.30	53	0.05	0.02	0.02	15.
1.02	3.00	54	0.05	0.02	0.02	18.
1.02	3.30	55	0.05	0.02	0.02	20.
1.02	4.00	56	0.05	0.02	0.02	21.
1.02	4.30	57	0.05	0.02	0.02	23.
1.02	5.00	58	0.05	0.02	0.02	24.
1.02	5.30	59	0.05	0.02	0.02	25.
1.02	6.00	60	0.05	0.02	0.02	26.
1.02	6.30	61	0.16	0.14	0.02	28.
1.02	7.00	62	0.16	0.14	0.02	33.
1.02	7.30	63	0.16	0.14	0.02	41.
1.02	8.00	64	0.16	0.14	0.02	52.
1.02	8.30	65	0.16	0.14	0.02	67.
1.02	9.00	66	0.16	0.14	0.02	82.
1.02	9.30	67	0.16	0.14	0.02	96.
1.02	10.00	68	0.16	0.14	0.02	108.
1.02	15.30	79	1.62	1.60	0.02	690.
1.02	16.00	80	5.13	5.10	0.02	662.
1.02	16.30	81	1.24	1.22	0.02	1086.
1.02	17.00	82	1.24	1.22	0.02	1333.
1.02	17.30	83	0.98	0.95	0.02	1560.
1.02	18.00	84	0.98	0.95	0.02	1724.
1.02	18.30	85	0.07	0.05	0.02	1792.
1.02	19.00	86	0.07	0.05	0.02	1749.
1.02	19.30	87	0.07	0.05	0.02	1634.
1.02	20.00	88	0.07	0.05	0.02	1488.
1.02	20.30	89	0.07	0.05	0.02	1326.
1.02	21.00	90	0.07	0.05	0.02	1163.
1.02	21.30	91	0.07	0.05	0.02	1014.
1.02	22.00	92	0.07	0.05	0.02	886.
1.02	22.30	93	0.07	0.05	0.02	774.
1.02	23.00	94	0.07	0.05	0.02	678.
1.02	23.30	95	0.07	0.05	0.02	595.
1.03	0.	96	0.07	0.05	0.02	523.
1.03	0.30	97	0.	0.	0.	461.
1.03	1.00	98	0.	0.	0.	405.
1.03	1.30	99	0.	0.	0.	356.
1.03	2.00	100	0.	0.	0.	311.
1.03	2.30	101	0.	0.	0.	270.
1.03	3.00	102	0.	0.	0.	234.
1.03	3.30	103	0.	0.	0.	202.
1.03	4.00	104	0.	0.	0.	175.
1.03	4.30	105	0.	0.	0.	151.
1.03	5.00	106	0.	0.	0.	130.
1.03	5.30	107	0.	0.	0.	112.
1.03	6.00	108	0.	0.	0.	97.
1.03	6.30	109	0.	0.	0.	84.
1.03	7.00	110	0.	0.	0.	72.
1.03	7.30	111	0.	0.	0.	62.
1.03	8.00	112	0.	0.	0.	54.
1.03	8.30	113	0.	0.	0.	46.
1.03	9.00	114	0.	0.	0.	39.
1.03	9.30	115	0.	0.	0.	33.
1.03	10.00	116	0.	0.	0.	27.
1.03	10.30	117	0.	0.	0.	22.
1.03	11.00	118	0.	0.	0.	18.
1.03	11.30	119	0.	0.	0.	14.
1.03	12.00	120	0.	0.	0.	8.
1.03	12.30	121	0.	0.	0.	6.
1.03	13.00	122	0.	0.	0.	4.
1.03	13.30	123	0.	0.	0.	3.
1.03	14.00	124	0.	0.	0.	3.
1.03	14.30	125	0.	0.	0.	2.
1.03	15.00	126	0.	0.	0.	2.
1.03	15.30	127	0.	0.	0.	2.
1.03	16.00	128	0.	0.	0.	2.
1.03	16.30	129	0.	0.	0.	2.
1.03	17.00	130	0.	0.	0.	1.
1.03	17.30	131	0.	0.	0.	1.
1.03	18.00	132	0.	0.	0.	1.
1.03	18.30	133	0.	0.	0.	1.
1.03	19.00	134	0.	0.	0.	1.
1.03	19.30	135	0.	0.	0.	1.
1.03	20.00	136	0.	0.	0.	1.
1.03	20.30	137	0.	0.	0.	1.
1.03	21.00	138	0.	0.	0.	1.
1.03	21.30	139	0.	0.	0.	1.
1.03	22.00	140	0.	0.	0.	0.
1.03	22.30	141	0.	0.	0.	0.
1.03	23.00	142	0.	0.	0.	0.
1.03	23.30	143	0.	0.	0.	0.

1.02	11.30	71	0.16	0.14	0.02	136.	1.04	1.00	146	0.	0.	0.	0.
1.02	12.00	72	0.16	0.14	0.02	143.	1.04	1.30	147	0.	0.	0.	0.
1.02	12.30	73	0.89	0.86	0.02	155.	1.04	2.00	148	0.	0.	0.	0.
1.02	13.00	74	0.89	0.86	0.02	185.	1.04	2.30	149	0.	0.	0.	0.
1.02	13.30	75	1.07	1.04	0.02	239.	1.04	3.00	150	0.	0.	0.	0.

SUM 22.72 20.40 2.32 27963.
(577.)(518.)(59.)(791.82)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1792.	1395.	559.	194.	27972.
CMS	51.	40.	16.	6.	792.
INCHES		12.16	19.49	20.32	20.32
MM		308.99	494.93	516.16	516.18
AC-FT		692.	1108.	1156.	1156.
THOUS CU M		853.	1367.	1426.	1426.

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	4.	8.	13.	18.	21.	23.	23.	21.
19.	17.	15.	13.	11.	9.	8.	7.	6.	6.
6.	6.	7.	8.	9.	10.	10.	11.	11.	12.
13.	15.	18.	24.	30.	37.	43.	49.	54.	58.
61.	64.	70.	83.	108.	145.	193.	250.	311.	388.
489.	600.	702.	776.	806.	787.	735.	670.	597.	523.
456.	399.	348.	305.	268.	235.	207.	182.	160.	140.
122.	105.	91.	79.	68.	59.	51.	44.	38.	33.
28.	24.	21.	17.	15.	12.	10.	8.	6.	4.
3.	2.	1.	1.	1.	1.	1.	1.	1.	1.
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	806.	628.	251.	87.	12587.
CMS	23.	18.	7.	2.	356.
INCHES		5.47	8.77	9.14	9.14
MM		139.05	222.72	232.27	232.28
AC-FT		311.	499.	520.	520.
THOUS CU M		384.	615.	642.	642.

HYDROGRAPH AT STA BASIN FOR PLAN 1, RTIO 2

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
1.	2.	4.	8.	13.	18.	22.	23.	23.	22.
20.	17.	15.	13.	11.	10.	8.	7.	6.	6.
6.	6.	7.	8.	9.	10.	11.	11.	12.	12.
13.	15.	19.	24.	31.	38.	44.	50.	55.	59.
63.	66.	71.	85.	110.	148.	198.	256.	318.	396.
500.	613.	718.	793.	824.	805.	751.	685.	610.	535.
467.	407.	356.	312.	274.	241.	212.	187.	164.	143.
124.	108.	93.	80.	69.	60.	52.	45.	39.	33.
29.	25.	21.	18.	15.	13.	10.	8.	7.	4.
3.	2.	1.	1.	1.	1.	1.	1.	1.	1.
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	824.	642.	257.	89.	12867.
CMS	23.	18.	7.	3.	364.

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                AC-FT                  692.     1108.     1156.          1156.
             THOUS CU M                853.     1367.     1426.          1426.


       **********          **********          **********          **********          **********

                                        HYDROGRAPH ROUTING

                          ROUTED OUTFLOW - SPILLCREST ELEV 425 - USGS  -  WITH BREACH
                              ISTAQ    ICOMP    IECON    ITAPE    JPLT    JPRT    INAME   ISTAGE   IAUTO
                                DAM        1        0        C       0       C        1        0       0
                                                  ROUTING DATA
                         QLOSS    CLOSS      AVG     IRES    ISAME    IOPT    IPMP             LSTR
                            0.       0.       0.        1        1       0       C                0

                              NSTPS    NSTDL      LAG    AMSKK        X      TSK    STORA   ISPRAT
                                  1        0        0       0.       0.       0.    -425.       -1

STAGE     425.00     425.50     426.00     426.50     427.00     427.50     427.80     428.00     428.50     428.80

 FLOW         0.      44.00     129.00     237.00     368.00     518.00     616.00     628.00     699.00     758.00

  CAPACITY=        1.       251.       308.

  ELEVATION=     389.       425.       429.

                           CREL    SPWID     COQW     EXPW    ELEVL     COQL    CAREA     EXPL
                          425.0       0.       0.       0.       0.       0.       0.       0.

                                                   DAM DATA
                                         TOPEL     COQD     EXPD   DAMWID
                                         428.8      3.1      1.5     382.

                                                DAM BREACH DATA
                                    BRWID        Z     ELBM    TFAIL     WSEL   FAILEL
                                      44.       0.   400.00     0.50   425.00   428.80

                                        STATION    DAM, PLAN 1, RATIO 1

                                       END-OF-PERIOD HYDROGRAPH ORDINATES

                                                  OUTFLOW
            0.        C.        0.        0.        0.        0.        0.        0.        0.        C.
            0.        C.        0.        0.        0.        0.        C.        0.        0.        C.
            0.        0.        0.        0.        0.        0.        C.        0.        0.        C.
            0.        C.        1.        2.        4.        6.        9.       12.       14.       16.
           17.       17.       17.       16.       15.       14.       13.       12.       11.       1C.
            9.        8.        8.        8.        8.        8.        9.        9.        9.       1C.
           10.       11.       12.       14.       17.       20.       25.       29.       34.       39.
           43.       5C.       56.       64.       76.       95.      123.      167.      219.      285.
          366.      47C.      560.      635.      686.      729.      743.      726.      689.      647.
          603.      496.      424.      367.      324.      286.      252.      224.      200.      177.
          156.      136.      121.      107.       94.       83.       72.       63.       54.       47.
           42.       39.       35.       32.       28.       25.       22.       19.       17.       14.
           12.       1C.        8.        7.        5.        4.        4.        3.        3.        2.
            2.        2.        1.        1.        1.        1.        1.        1.        1.        C.
            0.        C.        0.        0.        0.        0.        C.        0.        0.        C.

                                                  STORAGE
          251.      251.      251.      251.      251.      251.      251.      251.      251.      251.
          251.      251.      251.      251.      251.      251.      251.      251.      251.      251.
          251.      251.      251.      251.      251.      251.      251.      251.      251.      251.
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THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF 0.010 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF 0.500 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

46% × PMF

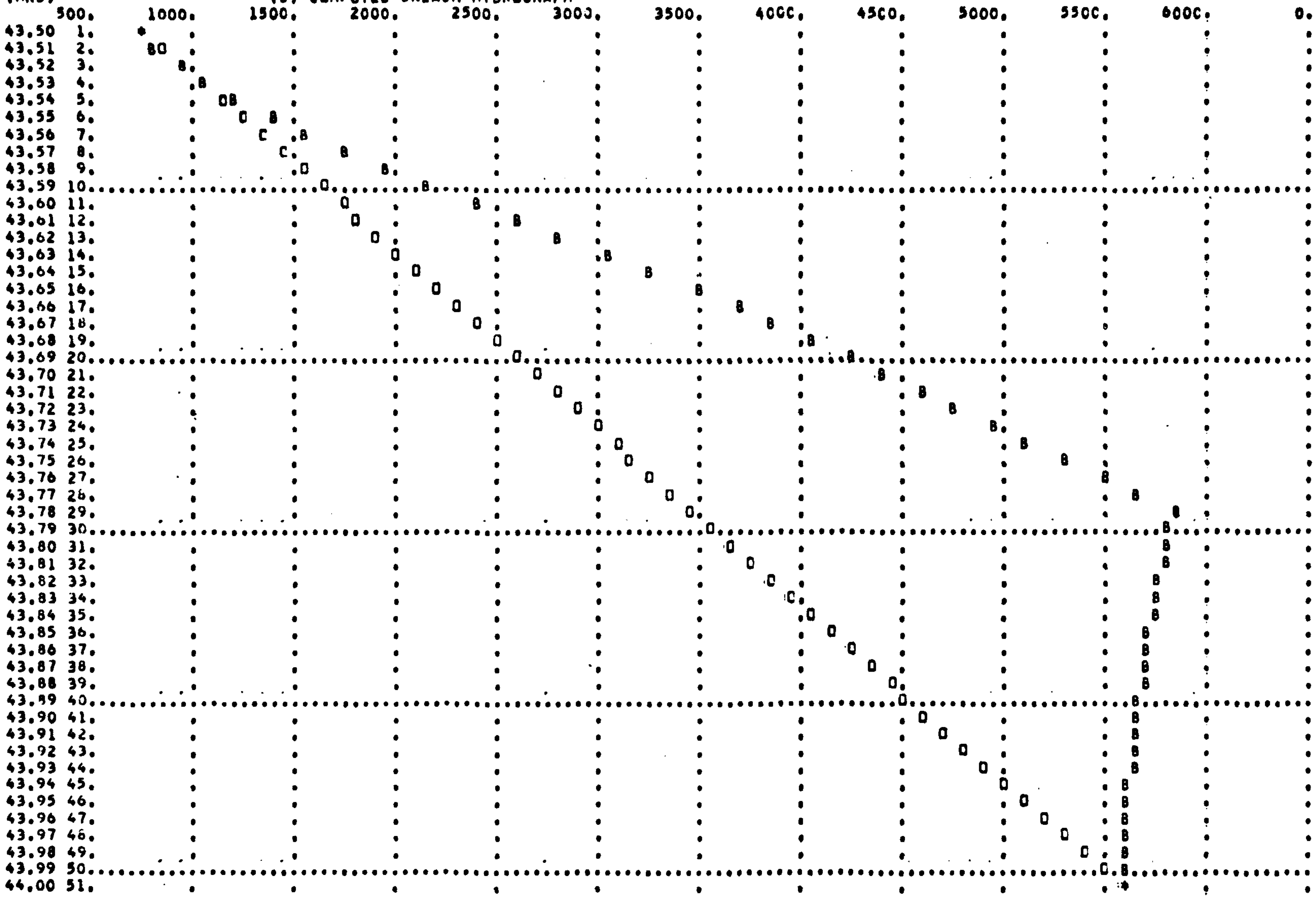
TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	-	COMPUTED BREACH HYDROGRAPH (CFS)	=	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
43.500	0.	761.		761.		0.	0.	C.
43.510	0.010	857.		820.		37.	37.	0.
43.520	0.020	954.		926.		28.	65.	C.
43.530	0.030	1050.		1060.		-9.	56.	C.
43.540	0.040	1147.		1214.		-68.	-12.	-C.
43.550	0.050	1243.		1385.		-142.	-154.	-C.
43.560	0.060	1340.		1568.		-229.	-382.	-C.
43.570	0.070	1436.		1761.		-325.	-707.	-1.
43.580	0.080	1533.		1962.		-429.	-1136.	-1.
43.590	0.090	1629.		2168.		-538.	-1675.	-1.
43.600	0.100	1726.		2382.		-656.	-2331.	-2.
43.610	0.110	1822.		2599.		-777.	-3107.	-3.
43.620	0.120	1919.		2818.		-900.	-4007.	-3.
43.630	0.130	2015.		3038.		-1023.	-5030.	-4.
43.640	0.140	2111.		3260.		-1149.	-6179.	-5.
43.650	0.150	2208.		3490.		-1282.	-7461.	-6.
43.660	0.160	2304.		3683.		-1378.	-8839.	-7.
43.670	0.170	2401.		3867.		-1466.	-10305.	-9.
43.680	0.180	2497.		4052.		-1555.	-11860.	-10.
43.690	0.190	2594.		4233.		-1639.	-13499.	-11.
43.700	0.200	2690.		4412.		-1722.	-15221.	-13.
43.710	0.210	2787.		4592.		-1806.	-17026.	-14.
43.720	0.220	2883.		4768.		-1884.	-18911.	-16.
43.730	0.230	2980.		4948.		-1968.	-20879.	-17.
43.740	0.240	3076.		5124.		-2047.	-22927.	-19.
43.750	0.250	3173.		5303.		-2131.	-25057.	-21.
43.760	0.260	3269.		5480.		-2211.	-27268.	-23.
43.770	0.270	3365.		5669.		-2304.	-29572.	-24.
43.780	0.280	3462.		5847.		-2385.	-31957.	-26.
43.790	0.290	3558.		5823.		-2265.	-34221.	-28.
43.800	0.300	3655.		5801.		-2146.	-36367.	-3C.
43.810	0.310	3751.		5781.		-2029.	-38397.	-32.
43.820	0.320	3848.		5762.		-1914.	-40311.	-33.
43.830	0.330	3944.		5745.		-1800.	-42111.	-35.
43.840	0.340	4041.		5729.		-1688.	-43799.	-36.
43.850	0.350	4137.		5714.		-1577.	-45376.	-38.
43.860	0.360	4234.		5700.		-1466.	-46842.	-39.
43.870	0.370	4330.		5687.		-1357.	-48200.	-4C.
43.880	0.380	4427.		5676.		-1249.	-49449.	-41.
43.890	0.390	4523.		5665.		-1142.	-50590.	-42.
43.900	0.400	4619.		5655.		-1035.	-51625.	-43.
43.910	0.410	4716.		5645.		-929.	-52554.	-43.
43.920	0.420	4812.		5636.		-824.	-53378.	-44.
43.930	0.430	4909.		5628.		-719.	-54098.	-45.
43.940	0.440	5005.		5620.		-615.	-54713.	-45.
43.950	0.450	5102.		5613.		-512.	-55224.	-46.
43.960	0.460	5198.		5607.		-408.	-55633.	-46.
43.970	0.470	5295.		5601.		-306.	-55939.	-46.
43.980	0.480	5391.		5595.		-204.	-56142.	-46.
43.990	0.490	5488.		5589.		-102.	-56244.	-46.
44.000	0.500	5584.		5584.		0.	-56244.	-46.

OVF

STATION DAM

TIME (HRS)

(C) INTERPOLATED BREACH HYDROGRAPH
(B) COMPUTED BREACH HYDROGRAPH
(*) POINTS AT NORMAL TIME INTERVAL



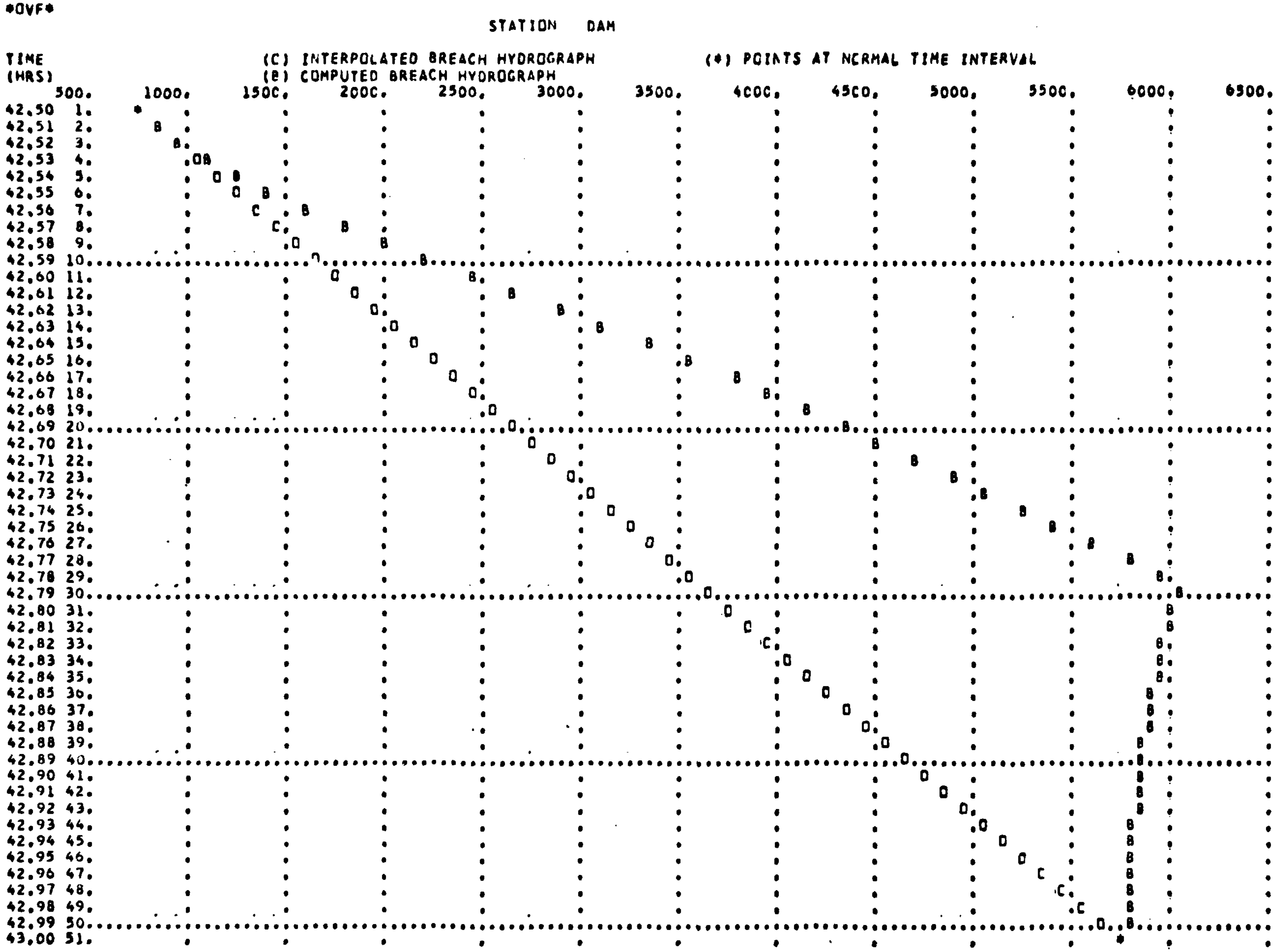
46% × PMF

THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF 0.010 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF 0.500 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

50% x PMF

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	-	COMPUTED BREACH HYDROGRAPH (CFS)	=	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
42.500	0.	765.		765.		0.	0.	0.
42.510	0.010	865.		830.		35.	35.	0.
42.520	0.020	965.		940.		25.	60.	0.
42.530	0.030	1065.		1077.		-12.	49.	0.
42.540	0.040	1165.		1234.		-69.	-20.	-0.
42.550	0.050	1266.		1409.		-144.	-164.	-0.
42.560	0.060	1366.		1598.		-232.	-396.	-0.
42.570	0.070	1466.		1796.		-330.	-727.	-1.
42.580	0.080	1566.		2002.		-436.	-1163.	-1.
42.590	0.090	1666.		2213.		-547.	-1710.	-1.
42.600	0.100	1766.		2429.		-662.	-2372.	-2.
42.610	0.110	1866.		2651.		-785.	-3157.	-3.
42.620	0.120	1967.		2876.		-909.	-4066.	-3.
42.630	0.130	2067.		3101.		-1034.	-5100.	-4.
42.640	0.140	2167.		3325.		-1158.	-6258.	-5.
42.650	0.150	2267.		3555.		-1288.	-7546.	-6.
42.660	0.160	2367.		3780.		-1413.	-8959.	-7.
42.670	0.170	2467.		3969.		-1501.	-10460.	-9.
42.680	0.180	2568.		4155.		-1588.	-12048.	-10.
42.690	0.190	2668.		4341.		-1673.	-13721.	-11.
42.700	0.200	2768.		4522.		-1754.	-15475.	-13.
42.710	0.210	2868.		4704.		-1836.	-17311.	-14.
42.720	0.220	2968.		4883.		-1915.	-19226.	-16.
42.730	0.230	3068.		5062.		-1993.	-21219.	-18.
42.740	0.240	3168.		5241.		-2072.	-23291.	-19.
42.750	0.250	3269.		5418.		-2150.	-25441.	-21.
42.760	0.260	3369.		5598.		-2230.	-27671.	-23.
42.770	0.270	3469.		5780.		-2311.	-29982.	-25.
42.780	0.280	3569.		5971.		-2402.	-32384.	-27.
42.790	0.290	3669.		6044.		-2375.	-34758.	-29.
42.800	0.300	3769.		6017.		-2248.	-37006.	-31.
42.810	0.310	3870.		5993.		-2124.	-39130.	-32.
42.820	0.320	3970.		5971.		-2001.	-41131.	-34.
42.830	0.330	4070.		5951.		-1881.	-43012.	-36.
42.840	0.340	4170.		5932.		-1762.	-44774.	-37.
42.850	0.350	4270.		5915.		-1645.	-46419.	-38.
42.860	0.360	4370.		5899.		-1529.	-47947.	-40.
42.870	0.370	4470.		5884.		-1414.	-49361.	-41.
42.880	0.380	4571.		5871.		-1300.	-50661.	-42.
42.890	0.390	4671.		5859.		-1188.	-51849.	-43.
42.900	0.400	4771.		5847.		-1076.	-52925.	-44.
42.910	0.410	4871.		5837.		-966.	-53891.	-45.
42.920	0.420	4971.		5827.		-856.	-54747.	-45.
42.930	0.430	5071.		5818.		-747.	-55493.	-46.
42.940	0.440	5172.		5810.		-638.	-56132.	-46.
42.950	0.450	5272.		5802.		-531.	-56663.	-47.
42.960	0.460	5372.		5795.		-424.	-57086.	-47.
42.970	0.470	5472.		5789.		-317.	-57403.	-47.
42.980	0.480	5572.		5783.		-211.	-57614.	-48.
42.990	0.490	5672.		5778.		-105.	-57719.	-48.
43.000	0.500	5772.		5772.		0.	-57719.	-48.

OVF


STATION DAM
TIME (HRS)
(C) INTERPOLATED BREACH HYDROGRAPH
(B) COMPUTED BREACH HYDROGRAPH
(*) POINTS AT NORMAL TIME INTERVAL
500. 1000. 1500. 2000. 2500. 3000. 3500. 4000. 4500. 5000. 5500. 6000. 6500.
42.50 1.
42.51 2.
42.52 3.
42.53 4.
42.54 5.
42.55 6.
42.56 7.
42.57 8.
42.58 9.
42.59 10.
42.60 11.
42.61 12.
42.62 13.
42.63 14.
42.64 15.
42.65 16.
42.66 17.
42.67 18.
42.68 19.
42.69 20.
42.70 21.
42.71 22.
42.72 23.
42.73 24.
42.74 25.
42.75 26.
42.76 27.
42.77 28.
42.78 29.
42.79 30.
42.80 31.
42.81 32.
42.82 33.
42.83 34.
42.84 35.
42.85 36.
42.86 37.
42.87 38.
42.88 39.
42.89 40.
42.90 41.
42.91 42.
42.92 43.
42.93 44.
42.94 45.
42.95 46.
42.96 47.
42.97 48.
42.98 49.
42.99 50.
43.00 51.

50% × PMF

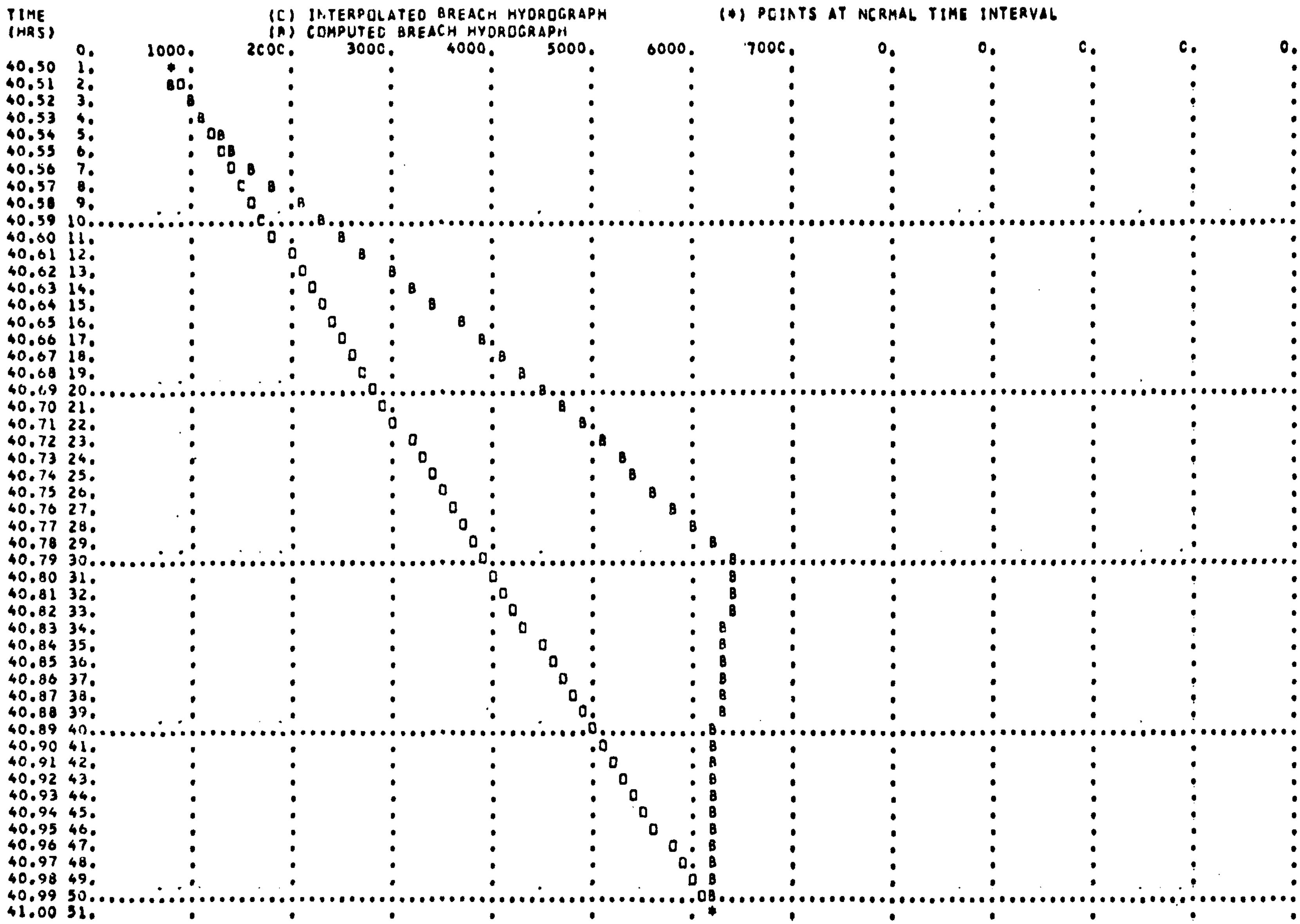
THE DAM BREACH HYDROGRAPH WAS DEVELOPED USING A TIME INTERVAL OF 0.010 HOURS DURING BREACH FORMATION.
DOWNSTREAM CALCULATIONS WILL USE A TIME INTERVAL OF 0.500 HOURS.
THIS TABLE COMPARES THE HYDROGRAPH FOR DOWNSTREAM CALCULATIONS WITH THE COMPUTED BREACH HYDROGRAPH.
INTERMEDIATE FLOWS ARE INTERPOLATED FROM END-OF-PERIOD VALUES.

PMF

TIME (HOURS)	TIME FROM BEGINNING OF BREACH (HOURS)	INTERPOLATED BREACH HYDROGRAPH (CFS)	-	COMPUTED BREACH HYDROGRAPH (CFS)	=	ERROR (CFS)	ACCUMULATED ERROR (CFS)	ACCUMULATED ERROR (AC-FT)
40.500	0.	766.		766.		0.	0.	0.
40.510	0.010	875.		839.		36.	36.	0.
40.520	0.020	983.		958.		25.	61.	0.
40.530	0.030	1091.		1103.		-12.	49.	0.
40.540	0.040	1200.		1268.		-68.	-19.	-0.
40.550	0.050	1308.		1445.		-137.	-156.	-0.
40.560	0.060	1416.		1635.		-219.	-375.	-0.
40.570	0.070	1525.		1840.		-316.	-691.	-1.
40.580	0.080	1633.		2054.		-421.	-1112.	-1.
40.590	0.090	1742.		2274.		-533.	-1645.	-1.
40.600	0.100	1850.		2498.		-648.	-2293.	-2.
40.610	0.110	1958.		2725.		-766.	-3060.	-3.
40.620	0.120	2067.		2956.		-890.	-3949.	-3.
40.630	0.130	2175.		3190.		-1015.	-4964.	-4.
40.640	0.140	2283.		3423.		-1140.	-6104.	-5.
40.650	0.150	2392.		3655.		-1264.	-7368.	-6.
40.660	0.160	2500.		3891.		-1391.	-8759.	-7.
40.670	0.170	2609.		4124.		-1516.	-10274.	-8.
40.680	0.180	2717.		4318.		-1601.	-11875.	-10.
40.690	0.190	2825.		4509.		-1684.	-13559.	-11.
40.700	0.200	2934.		4699.		-1765.	-15323.	-13.
40.710	0.210	3042.		4883.		-1841.	-17165.	-14.
40.720	0.220	3151.		5070.		-1919.	-19084.	-16.
40.730	0.230	3259.		5252.		-1993.	-21077.	-17.
40.740	0.240	3367.		5435.		-2067.	-23145.	-19.
40.750	0.250	3476.		5617.		-2142.	-25286.	-21.
40.760	0.260	3584.		5799.		-2215.	-27501.	-23.
40.770	0.270	3692.		5981.		-2289.	-29790.	-25.
40.780	0.280	3801.		6168.		-2368.	-32157.	-27.
40.790	0.290	3909.		6362.		-2452.	-34610.	-29.
40.800	0.300	4018.		6408.		-2391.	-37001.	-31.
40.810	0.310	4126.		6381.		-2255.	-39255.	-32.
40.820	0.320	4234.		6356.		-2121.	-41377.	-34.
40.830	0.330	4343.		6333.		-1990.	-43367.	-36.
40.840	0.340	4451.		6313.		-1862.	-45229.	-37.
40.850	0.350	4559.		6295.		-1736.	-46965.	-39.
40.860	0.360	4668.		6279.		-1611.	-48576.	-40.
40.870	0.370	4776.		6265.		-1488.	-50064.	-41.
40.880	0.380	4885.		6252.		-1367.	-51431.	-43.
40.890	0.390	4993.		6241.		-1248.	-52679.	-44.
40.900	0.400	5101.		6231.		-1129.	-53808.	-44.
40.910	0.410	5210.		6222.		-1012.	-54820.	-45.
40.920	0.420	5318.		6215.		-896.	-55717.	-46.
40.930	0.430	5427.		6208.		-782.	-56498.	-47.
40.940	0.440	5535.		6203.		-668.	-57166.	-47.
40.950	0.450	5643.		6198.		-555.	-57720.	-48.
40.960	0.460	5752.		6194.		-442.	-58163.	-48.
40.970	0.470	5860.		6191.		-331.	-58494.	-48.
40.980	0.480	5968.		6188.		-220.	-58713.	-49.
40.990	0.490	6077.		6187.		-110.	-58823.	-49.
41.000	0.500	6185.		6185.		0.	-58823.	-49.

OVF

STATION DAM



PMF

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**********          **********          **********          **********          **********

                                        HYDROGRAPH ROUTING

                           CHANNEL ROUTING OF   BREACH   TO STATION 4.5
                              ISTAQ    ICOMP    IECON    ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                              UPTRB        1        0        0       0       0       1       0       0
                                                   ROUTING DATA
                        QLOSS    CLOSS      AVG     IRES    ISAME    IOPT    IPMP            LSTR
                           0.       0.       0.        1        1       0       0               0

                              NSTPS    NSTOL      LAG    AMSKK        X     TSK   STORA  ISPRAT
                                  4        0        0       0.       0.      0.      0.       0

NORMAL DEPTH CHANNEL ROUTING
----------------------------

      QN(1)    QN(2)    QN(3)    ELNVT    ELMAX    RLNTH      SEL
     0.0400   0.0400   0.0400    280.0    300.0    9750.  0.01149

      CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
         10.00  292.00   40.00  287.00   50.00  285.00   55.00  280.00   65.00  280.00
         70.00  285.00   80.00  287.00  110.00  292.00

 STORAGE        0.        2.60        5.70        9.30       13.39       18.04       24.62       33.70       45.65       60.58
             78.49       99.37      122.69      146.25      169.82      193.38      216.94      240.50      264.06      287.62

 OUTFLOW        0.       43.19      139.05      280.20      466.78      714.24     1078.33     1564.02     2209.96     3056.10
           4134.38     5474.21     7252.52     9415.60    11843.25    14520.52    17435.43    20578.10    23940.15    27514.35

   STAGE    280.00      281.05      282.11      283.16      284.21      285.26      286.32      287.37      288.42      289.47
            290.53      291.58      292.63      293.68      294.74      295.79      296.84      297.89      298.95      300.00

    FLOW        0.       43.19      139.05      280.20      466.78      714.24     1078.33     1564.02     2209.96     3056.10
           4134.38     5474.21     7252.52     9415.60    11843.25    14520.52    17435.43    20578.10    23940.15    27514.35

                                   STATION   UPTRB, PLAN 1, RTIO 1

                                               OUTFLOW
                 0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
                 0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
                 0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
                 0.        0.        0.        1.        2.        3.        5.        8.       11.       13.
                15.       16.       17.       17.       16.       16.       15.       13.       12.       11.
                10.        9.        9.        8.        8.        8.        8.        8.        9.        9.
                10.       10.       11.       12.       13.       16.       19.       23.       27.       32.
                36.       42.       51.       58.       66.       80.      101.      134.      186.      244.
               319.      415.      527.      618.      663.      709.      742.      736.      707.      667.
               623.      551.      456.      394.      348.      305.      272.      241.      214.      191.
               169.      148.      132.      118.      104.       92.       80.       70.       61.       53.
                46.       42.       40.       37.       33.       30.       27.       24.       21.       18.
                15.       13.       11.        9.        7.        6.        5.        4.        3.        3.
                 2.        2.        2.        1.        1.        1.        1.        1.        1.        1.
                 0.        0.        0.        0.        0.        0.        0.        0.        0.        0.

                                                 STOR
```

```
                         CMS       116.       40.       18.        6.          878.
                      INCHES               14.82     21.73     22.52         22.52
                          MM              376.34    551.82    571.94        571.97
                       AC-FT                843.     1236.     1281.         1281.
                   THOUS CU M              1039.     1524.     1580.         1580.

                                 MAXIMUM STORAGE =       19.

MAXIMUM STAGE IS      290.5


        *********          *********          *********          *********          *********

                                        HYDROGRAPH ROUTING

                         CHANNEL ROUTING OF   BREACH   TO STATION TC
                            ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                           LOWTRB       1       0       0       0       0       1       0       0
                                                  ROUTING DATA
                   QLOSS    CLOSS     AVG    IRES   ISAME    IOPT    IPMP            LSTR
                      0.       0.      0.       1       1       0       0               0

                            NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                                1       0       0      0.      0.      0.      0.       0

NORMAL DEPTH CHANNEL ROUTING
----------------------------

         QN(1)     QN(2)     QN(3)     ELNVT     ELMAX     RLNTH       SEL
        0.0400    0.0400    0.0400     233.0     280.0      450.   0.10440

         CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC
           35.00  250.00   45.00  240.00   50.00  238.00   55.00  233.00   65.00  233.00
           70.00  238.00   75.00  240.00   85.00  250.00

STORAGE           0.         0.32         0.76         1.42         2.28         3.25         4.36         5.59         6.86         8.14
                9.42        10.70        11.98        13.25        14.53        15.81        17.09        18.36        19.64        20.92

OUTFLOW           0.       552.67      1885.02      4604.20      8779.72     14357.98     21391.36     30068.92     41141.72     53725.20
            67726.37     83072.57     99704.63    117572.85    136634.64    156852.83    178194.58    200630.54    224134.25    248681.67

STAGE         233.00       235.47       237.95       240.42       242.89       245.37       247.84       250.32       252.79       255.26
              257.74       260.21       262.68       265.16       267.63       270.11       272.58       275.05       277.53       280.00

FLOW              0.       552.67      1885.02      4604.20      8779.72     14357.98     21391.36     30068.92     41141.72     53725.20
            67726.37     83072.57     99704.63    117572.85    136634.64    156852.83    178194.58    200630.54    224134.25    248681.67

                                  STATION  LOWTRB, PLAN 1, RTIO 1

                                              OUTFLOW
               0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
               0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
               0.        0.        0.        0.        0.        0.        0.        0.        0.        0.
               0.        0.        0.        1.        2.        3.        5.        8.       10.       13.
              15.       16.       17.       17.       16.       16.       15.       13.       12.       11.
              10.        9.        9.        8.        8.        8.        8.        8.        9.        9.
              10.       10.       11.       12.       13.       16.       19.       23.       27.       32.
              36.       42.       51.       58.       66.       80.      101.      133.      185.      244.
             318       413.      525.      618.      662.      709.      741.      736.      707.      667.
             623.      553       457       395       349   [illegible]
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FORMULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

CHURCHTOWN
RESERVOIR
DAM

[W/ BREACH]

OPERATION	STATION	AREA	PLAN	RATIO 1 0.45	RATIO 2 0.46	RATIO 3 0.50	RATIO 4 1.00
				RATIOS APPLIED TO FLOWS			
HYDROGRAPH AT	BASIN	1.07	1	806.	824.	896.	1792.
		(-0.00)	(	22.83)(	23.34)(	25.37)(	50.74)(
ROUTED TO	DAM	1.07	1	743.	5584.	5772.	6185.
		(0.12E 25)	(	21.04)(	158.12)(	163.46)(	175.15)(
ROUTED TO	UPTRB	1.07	1	742.	3538.	3660.	4087.
		(-0.00)	(	21.01)(	100.20)(	103.65)(	115.73)(
ROUTED TO	LOWTRB	1.07	1	741.	3561.	3684.	4112.
		(-0.00)	(	20.99)(	100.84)(	104.31)(	116.43)(

SUMMARY OF DAM SAFETY ANALYSIS

CHURCHTOWN RESERVOIR DAM [W/ BREACH]

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	425.00	425.00	428.80
STORAGE	251.	251.	308.
OUTFLOW	0.	0.	758.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
0.45	428.72	0.	307.	743.	0.	43.50	0.
0.46	428.81	0.01	308.	5847.	0.52	43.78	43.50
0.50	428.82	0.02	308.	6044.	0.54	42.79	42.50
1.00	428.85	0.05	309.	6408.	0.56	40.80	40.50

PLAN 1 STATION UPTRB

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.45	742.	285.3	43.50
0.46	3538.	289.9	44.50
0.50	3660.	290.1	43.50
1.00	4087.	290.5	41.50

PLAN 1 STATION LOWTRB

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
0.45	741.	235.8	43.50
0.46	3561.	239.5	44.50
0.50	3684.	239.6	43.50
1.00	4112.	240.0	41.50

APPENDIX D

STABILITY COMPUTATIONS

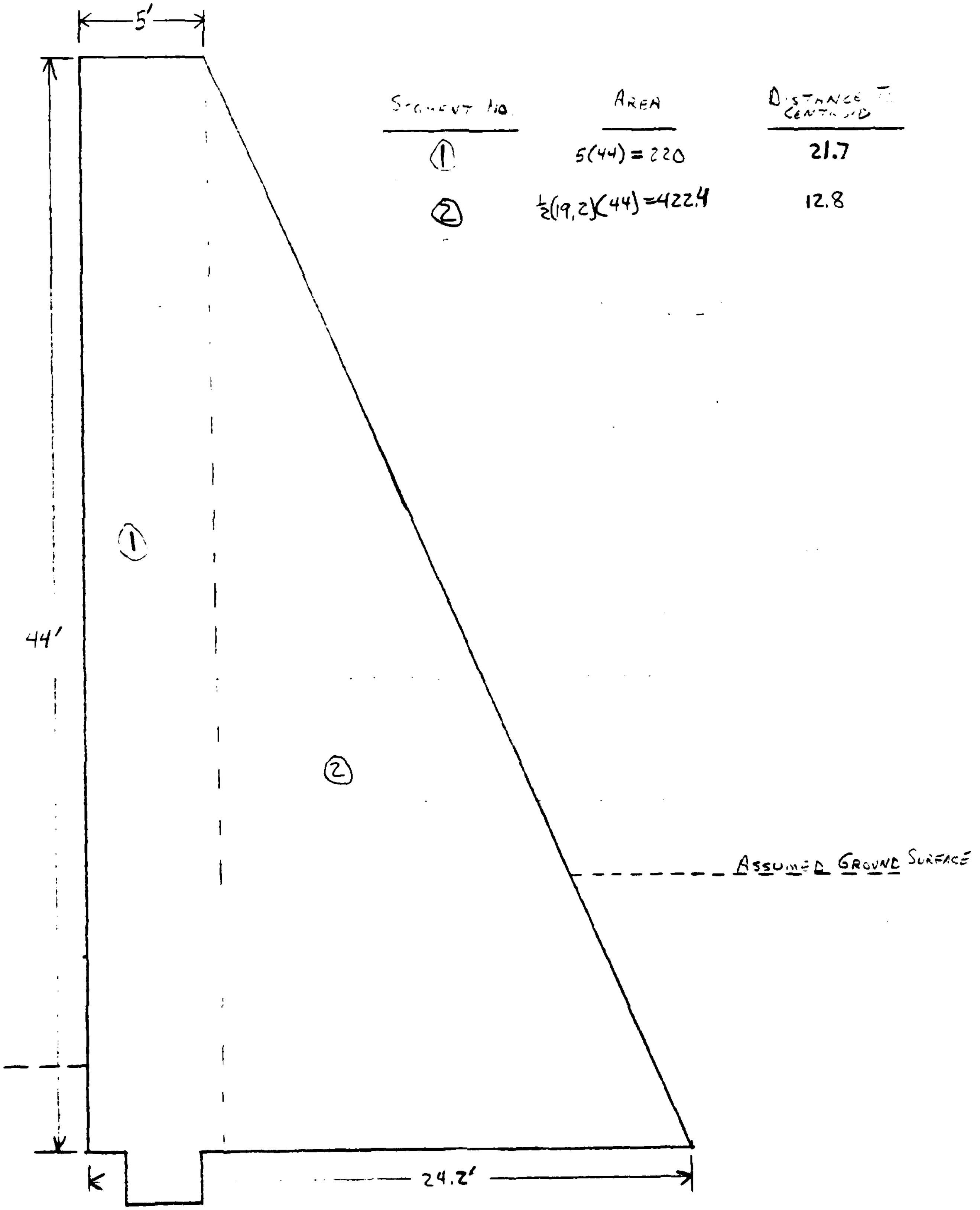
STRUCTURAL STABILITY ANALYSIS CONDITIONS

1. Normal conditions; water surface at spillway crest.
2. Same as #1 plus ice load of 5,000 pounds per linear foot.
3. Flood flows - water surface at top of dam.
4. 1/2 PMF flow - water surface 0.18 feet above crest of dam.
5. PMF flow - water surface 0.81 feet above crest of dam.
6. Normal conditions; with seismic coefficient of 0.1.

CHURCHTOWN DAM

SCALE 1" = 5'

SEGMENT NO.	AREA	DISTANCE TO CENTROID
1	5(44) = 220	21.7
2	½(19.2)(44) = 422.4	12.8



00-15-1 (3/78)
Formerly GA-17

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

PROJECT GRID

JOB	SHEET NO.	CHECKED BY	DATE
CHURCHTOWN DAM	1		
SUBJECT: STRUCTURAL STABILITY ANALYSIS		COMPUTED BY: RLW	DATE: 2/23/81

ANALYZE 2 CONDITIONS

1. FULL DAM SECTION

2. MID DAM SECTION - ASSUME A FAILURE ALONG JOINT BETWEEN BLOCKS

FOR FULL DAM SECTION

CALCULATE SHEARING RESISTENCE OF KEY

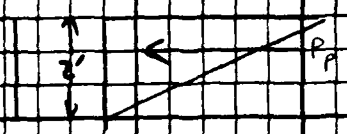
1. COMPUTE SHEAR STRENGTH OF CONCRETE

ASSUME 2000 psi CONCRETE

SHEAR STRENGTH $= 2\sqrt{f'_c} = 2\sqrt{2000} = 89.44$ psi

$$\frac{(\text{STRENGTH})(\text{AREA/FOOT})}{1000\ ^{lb}/_{k}} = \frac{(89.44\ psi)(432\ in^2/ft)}{1000\ ^{lb}/_{k}} = 38.64\ ^{k}/_{ft}$$

CALCULATE PASSIVE RESISTANCE AVAILABLE



$P_p = \frac{1}{2}(3.0)(.055)(2)^2 = 0.33\ ^{k}/_{ft}$

∴ USE THIS VALUE FOR SHEAR KEY RESISTANCE

STABILITY ANALYSIS PROGRAM - WORK SHEET

FULL DAM SECTION

INPUT ENTRY		ANALYSIS CONDITION 1	2	3	4	5	
Unit Weight of Dam (K/ft^3)	0	0.15					
Area of Segment No. 1 (ft^2)	1	220					
Distance from Center of Gravity of Segment No. 1 to Downstream Toe (ft)	2	21.7					
Area of Segment No. 2 (ft^2)	3	422.4					
Distance from Center of Gravity of Segment No. 2 to Downstream Toe (ft)	4	12.8					
Area of Segment No. 3 (ft^2)	5						
Distance from Center of Gravity of Segment No. 3 to Downstream Toe (ft)	6						
Base Width of Dam (Total) (ft)	7	24.2					
Height of Dam (ft)	8	44					
Ice Loading (K/L ft.)	9		5.0				
Coefficient of Sliding	10	0.60					
Unit Weight of Soil (K/ft^3) (deduct 18)	11	.055					
Active Soil Coefficient - Ka	12	.33					
Passive Soil Coefficient - Kp	13	3.0					
Height of Water over Top of Dam or Spillway (ft)	14			3.8	3.98	4.61	
Height of Soil for Active Pressure (ft)	15	3.5					
Height of Soil for Passive Pressure (ft)	16	13.0					
Height of Water in Tailrace Channel (ft)	17	13.0					
Weight of Water (K/ft^3)	18	0.0624					
SHEAR KEY RESISTANCE	58	.333					
Area of Segment No. 4 (ft^2)	19						
Distance from Center of Gravity of Segment No. 4 to Downstream Toe (ft)	20						
Height of Ice Load or Active Water (ft) (does not include 14)	46	40.2					
Seismic Coefficient (g)	50						0.1

RESULTS OF ANALYSIS	1	2	3	4	5	
Factor of Safety vs. Overturning	1.29	1.11	1.09	1.08	1.06	1.20
Distance From Toe to Resultant	6.51	2.93	2.42	2.23	1.55	4.89
Factor of Safety vs. Sliding	1.05	0.96	0.87	0.87	0.84	0.81

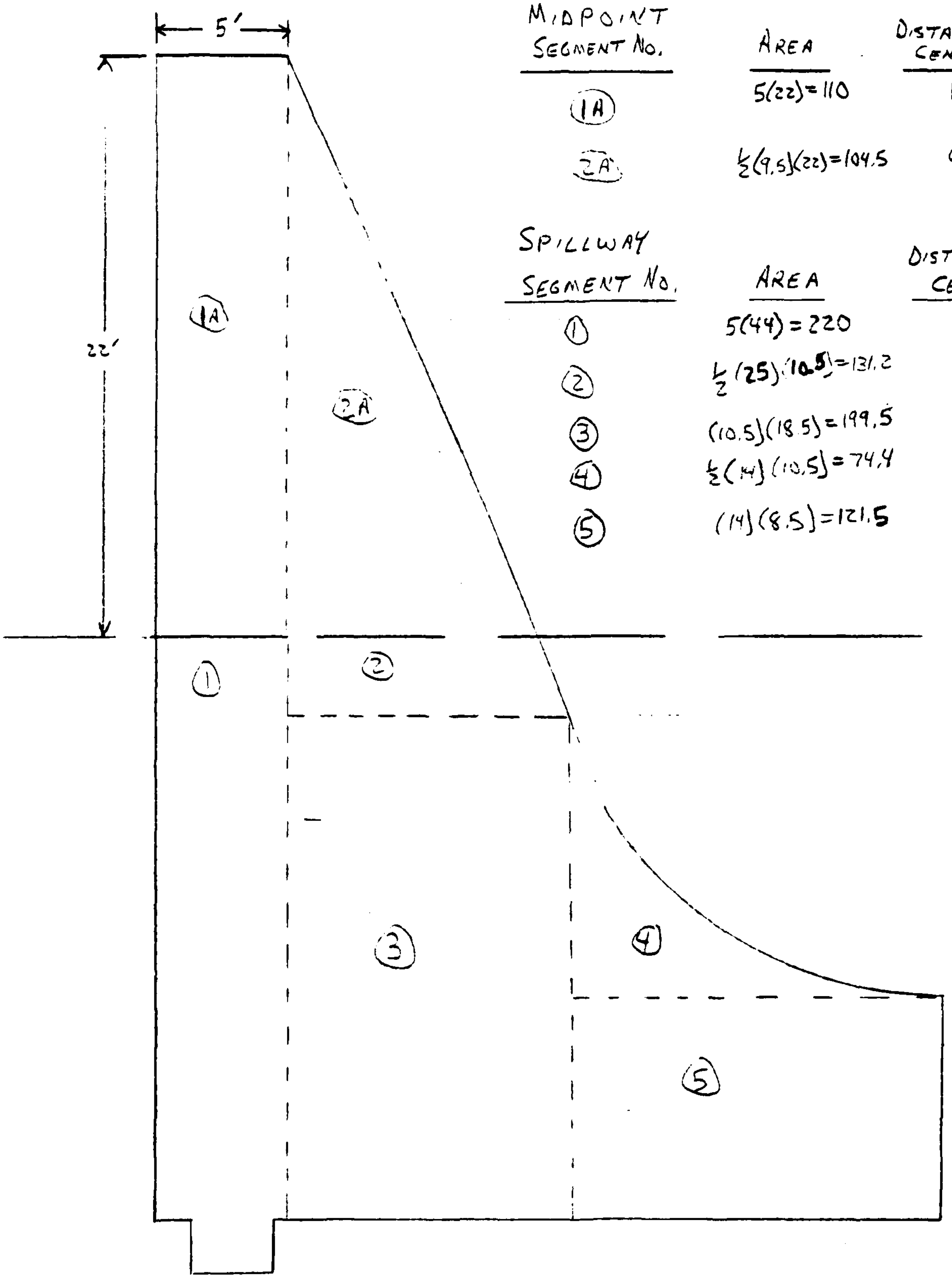
CHURCHTOWN DAM

SECTION TAKEN AT MIDPOINT AND SPILLWAY SECTION

SCALE 1"=50'

MIDPOINT SEGMENT NO.	AREA	DISTANCE TO CENTROID
1A	5(22)=110	12
2A	½(9.5)(22)=104.5	6.3

SPILLWAY SEGMENT NO.	AREA	DISTANCE TO CENTROID
1	5(44)=220	27.3
2	½(25)(10.5)=131.2	21.3
3	(10.5)(18.5)=199.5	19.5
4	½(14)(10.5)=74.4	9.5
5	(14)(8.5)=121.5	7.1



STABILITY ANALYSIS PROGRAM - WORK SHEET

SPILLWAY SECTION

INPUT ENTRY		ANALYSIS CONDITION 1	2	3	4	5	6
Unit Weight of Dam (K/ft^3)	0	0.15					
Area of Segment No. 1 (ft^2)	1	220					
Distance from Center of Gravity of Segment No. 1 to Downstream Toe (ft)	2	27.3					
Area of Segment No. 2 (ft^2)	3	131.2					
Distance from Center of Gravity of Segment No. 2 to Downstream Toe (ft)	4	21.3					
Area of Segment No. 3 (ft^2)	5	199.5					
Distance from Center of Gravity of Segment No. 3 to Downstream Toe (ft)	6	19.5					
Base Width of Dam (Total) (ft)	7	29.7					
Height of Dam (ft)	8	40.2					
Ice Loading (K/L ft.)	9		5				
Coefficient of Sliding	10	0.60					
Unit Weight of Soil (K/ft^3) (deduct 18)	11	0.55					
Active Soil Coefficient - Ka	12	0.33					
Passive Soil Coefficient - Kp	13	3.0					
Height of Water over Top of Dam or Spillway (ft)	14			3.8	3.98	4.61	
Height of Soil for Active Pressure (ft)	15	3.5					
Height of Soil for Passive Pressure (ft)	16	13.0					
Height of Water in Tailrace Channel (ft)	17	13.0					
Weight of Water (K/ft^3)	18	.0624					
Area of Segment No. 4 (ft^2)	19	74.4					
Distance from Center of Gravity of Segment No. 4 to Downstream Toe (ft)	20	9.5					
Height of Ice Load or Active Water (ft) (does not include 14)	46	40.2					
Seismic Coefficient (g)	50						0.1
SHEAR KEY RESISTENCE	58	0.333					
AREA SEGMENT 5	21	121.5					
DIST. TO CENT.	22	7.1					
RESULTS OF ANALYSIS							
Factor of Safety vs. Overturning		1.80	1.59	1.60	1.59	1.57	1.70
Distance From Toe to Resultant		19.66	16.45	16.60	16.45	15.94	18.2[illegible]
Factor of Safety vs. Sliding		3.54	3.23	2.99	2.97	2.89	2.67

STABILITY ANALYSIS PROGRAM - WORK SHEET

FAILURE PLANE IN MIDDLE OF DAM

INPUT ENTRY		ANALYSIS CONDITION 1	2	3	4	5	6
Unit Weight of Dam (K/ft^3)	0	0.15					
Area of Segment No. 1 (ft^2)	1	110					
Distance from Center of Gravity of Segment No. 1 to Downstream Toe (ft)	2	12					
Area of Segment No. 2 (ft^2)	3	104.5					
Distance from Center of Gravity of Segment No. 2 to Downstream Toe (ft)	4	6.3					
Area of Segment No. 3 (ft^2)	5						
Distance from Center of Gravity of Segment No. 3 to Downstream Toe (ft)	6						
Base Width of Dam (Total) (ft)	7	14.5					
Height of Dam (ft)	8	22					
Ice Loading (K/L ft.)	9		5				
Coefficient of Sliding	10	.60					
Unit Weight of Soil (K/ft^3) (deduct 18)	11	.055					
Active Soil Coefficient - Ka	12	.33					
Passive Soil Coefficient - Kp	13	3.0					
Height of Water over Top of Dam or Spillway (ft)	14			3.8	3.98	4.61	
Height of Soil for Active Pressure (ft)	15						
Height of Soil for Passive Pressure (ft)	16						
Height of Water in Tailrace Channel (ft)	17						
Weight of Water (K/ft^3)	18	.0624					
Area of Segment No. 4 (ft^2)	19						
Distance from Center of Gravity of Segment No. 4 to Downstream Toe (ft)	20						
Height of Ice Load or Active Water (ft) (does not include 14)	46	18.2					
Seismic Coefficient (g)	50						0.1

RESULTS OF ANALYSIS

	1	2	3	4	5	6
Factor of Safety vs. Overturning	2.08	1.27	1.49	1.46	1.40	1.9[illegible]
Distance From Toe to Resultant	6.45	2.65	4.05	3.94	3.54	6.09
Factor of Safety vs. Sliding	1.39	.94	0.92	0.91	0.86	0.9[illegible]

APPENDIX E

REFERENCES

APPENDIX

REFERENCES

1) M.G. Cline and R.L. Marshall, Soils of New York Landscapes - Information Bulletin 119, New York State College of Agriculture and Life Sciences, Cornell University, August 1977.

2) B.B. Eissler, Low - Flow Frequency Analysis of Streams in New York - Bulletin 74, U.S. Geological Survey, 1979.

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5) N.S. Hill Jr., Report on Condition of Dam, March 27, 1914.

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7) H.G. Lewis and D.F. Kinsman, Soil Survey of Columbia County, NY - No. 45 Series 1923, U.S. Department of Agriculture, 1929.

AD-A105 728 NEW YORK STATE DEPT OF ENVIRONMENTAL CONSERVATION ALBANY F/G 13/13
NATIONAL DAM SAFETY PROGRAM. CHURCHTOWN DAM (INVENTORY NUMBER N--ETC(U)
FEB 81 G KOCH DACW51-79-C-0001

UNCLASSIFIED NL

2 OF 2
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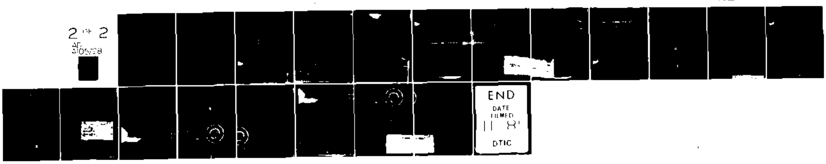


U.S. Army Corps of Engineers:

8) HEC-1 Flood Hydrograph Package - Dam Safety Version, September 1978.

Engineering Manual 1110-2-1405; Flood-Hydrograph Analysis and Computations, August 1959.

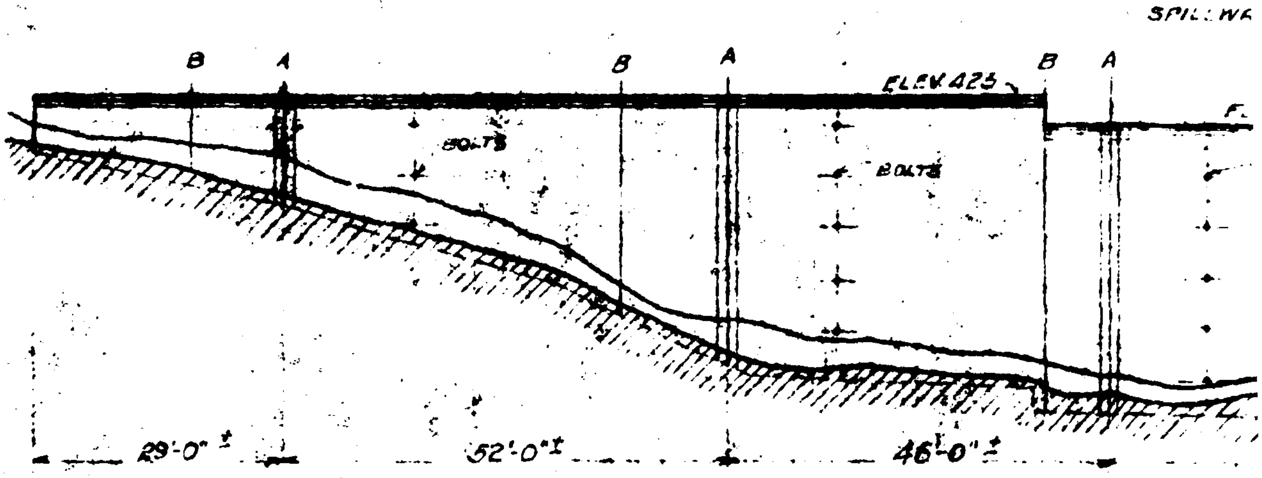
10) U.S. Department of Agriculture, Soil Conservation Service; National Engineering Handbook; Section 4-Hydrology, August 1972.

11) U.S. Department of Commerce; Weather Bureau; Hydrometerological Report No. 33: Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24, and 48 Hours, April 1956.

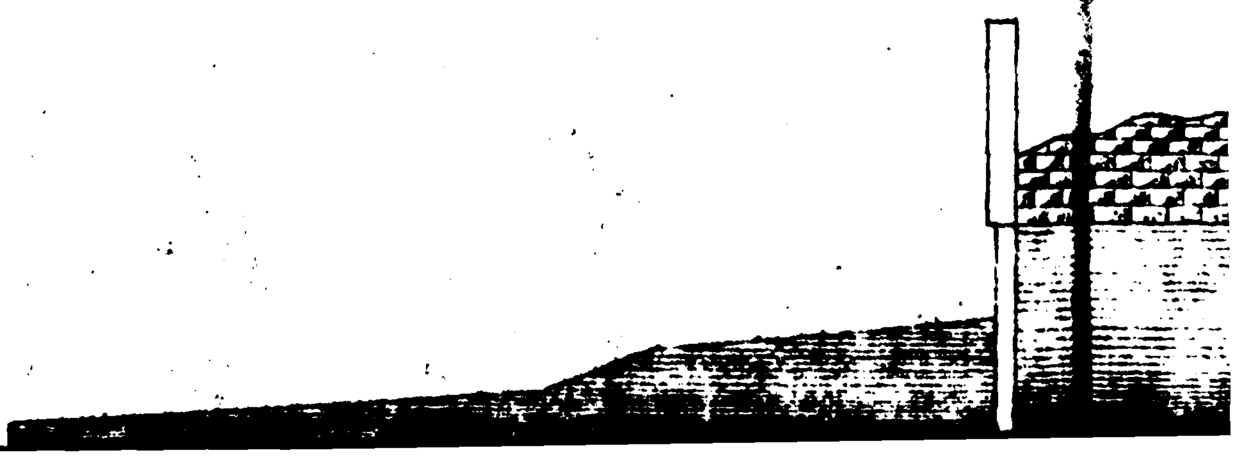
12) U.S. Geological Survey, Water Resources Data for New York - 1979; Volume 1 - Excluding Long Island.

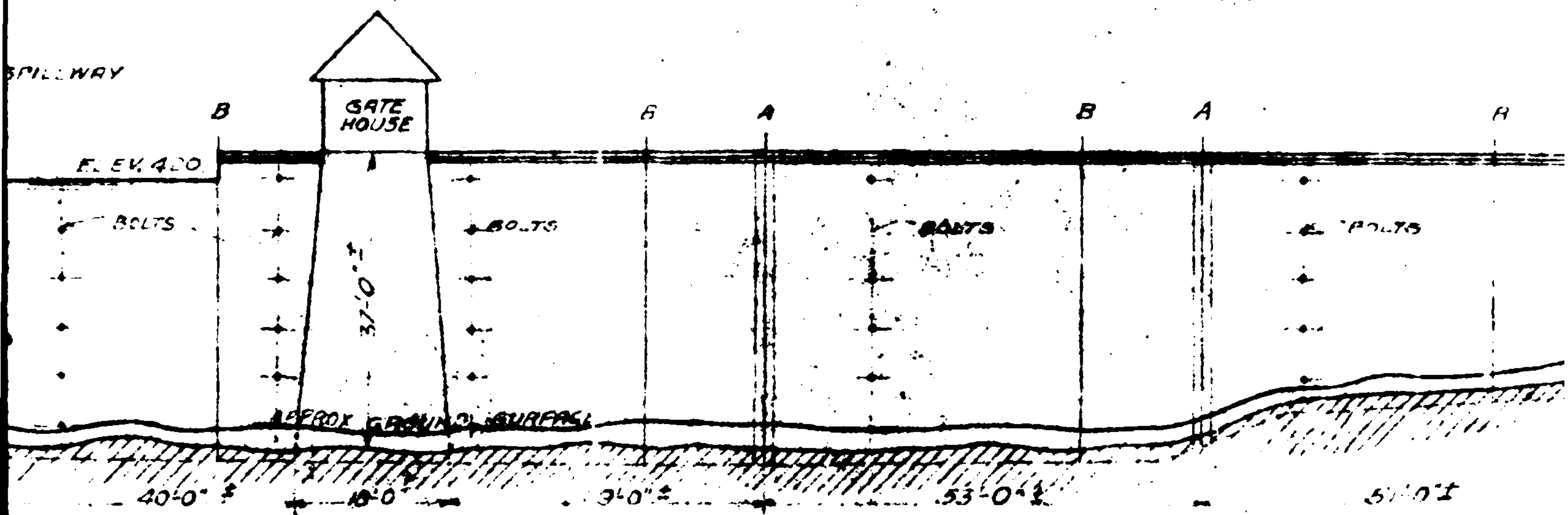
APPENDIX F

REFERENCES



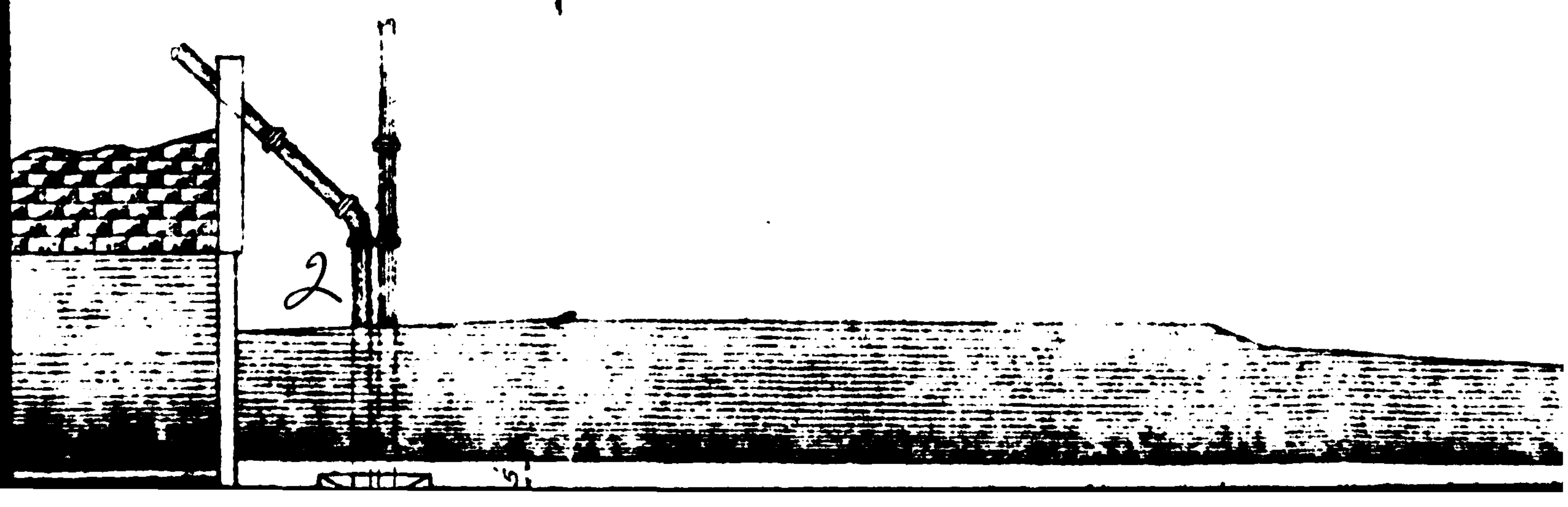
A. Ind
in c
B. Ind
joi

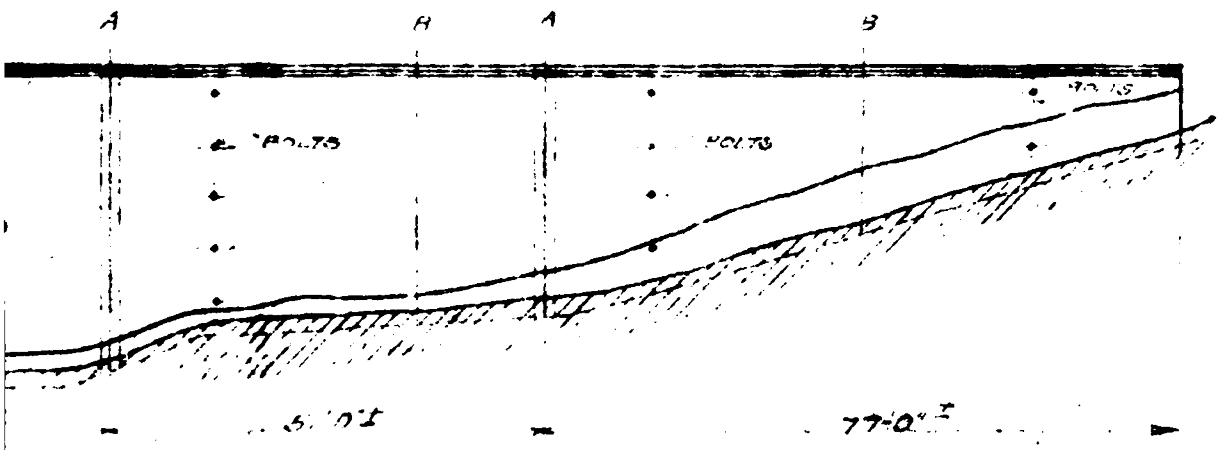


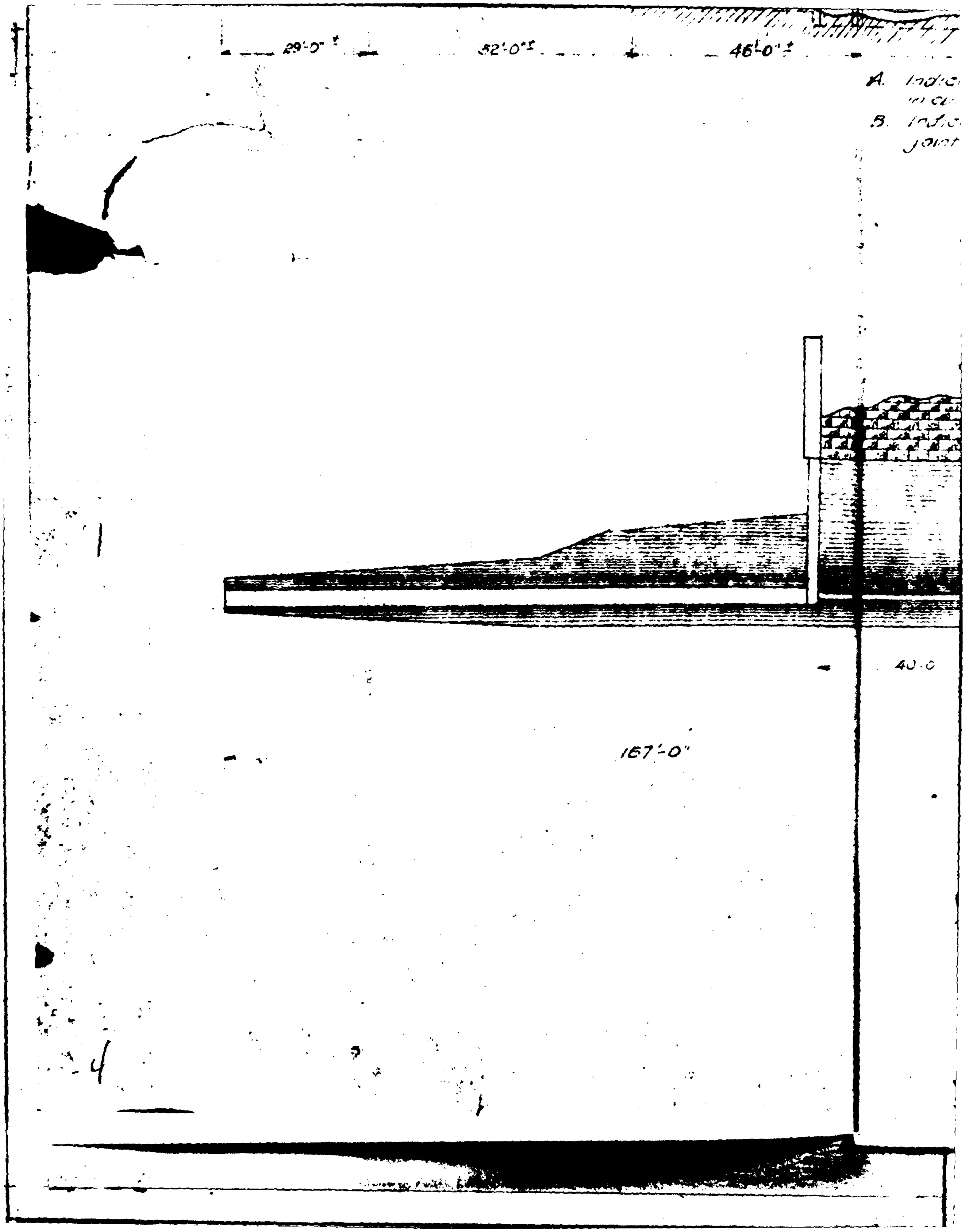


Indicates approximate location of construction joints in cut off wall.

B Indicates approximate location of present expansion joints in dam.



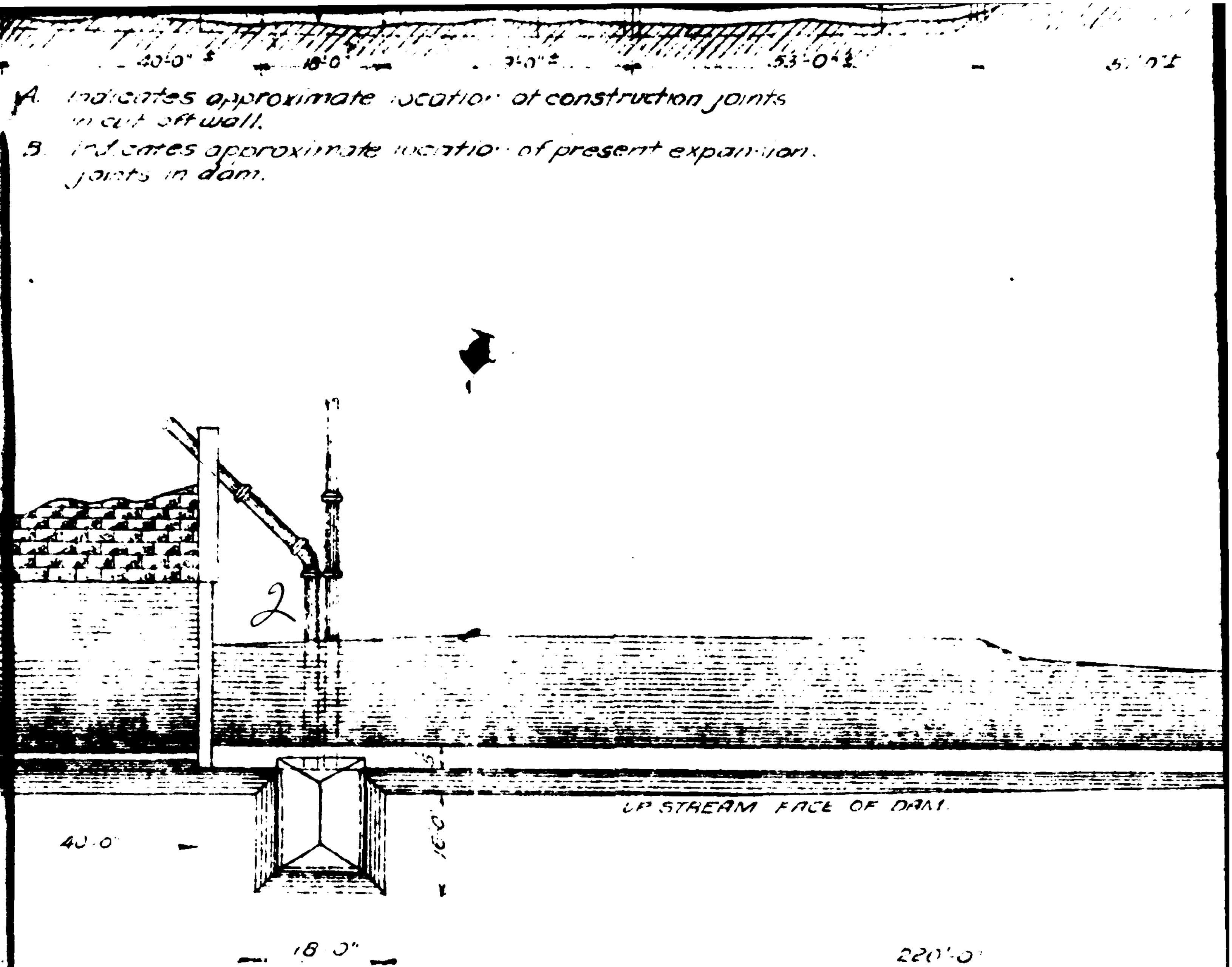

A
B
A
B
BOLTS
BOLTS



29'-0" ±
52'-0" ±
46'-0" ±
A. Indic
in cu
B. Indic
joint
40'-0
167'-0"

A. Indicates approximate location of construction joints in cut off wall.

B. Indicates approximate location of present expansion joints in dam.



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162

STATE OF NEW YORK
CONSERVATION COMMISSION
DIVISION OF INLAND WATERS

Albany, N. Y.

This is to certify that this plan with the ... specifications, for ... No. 1009 ... Watershed, have been ...

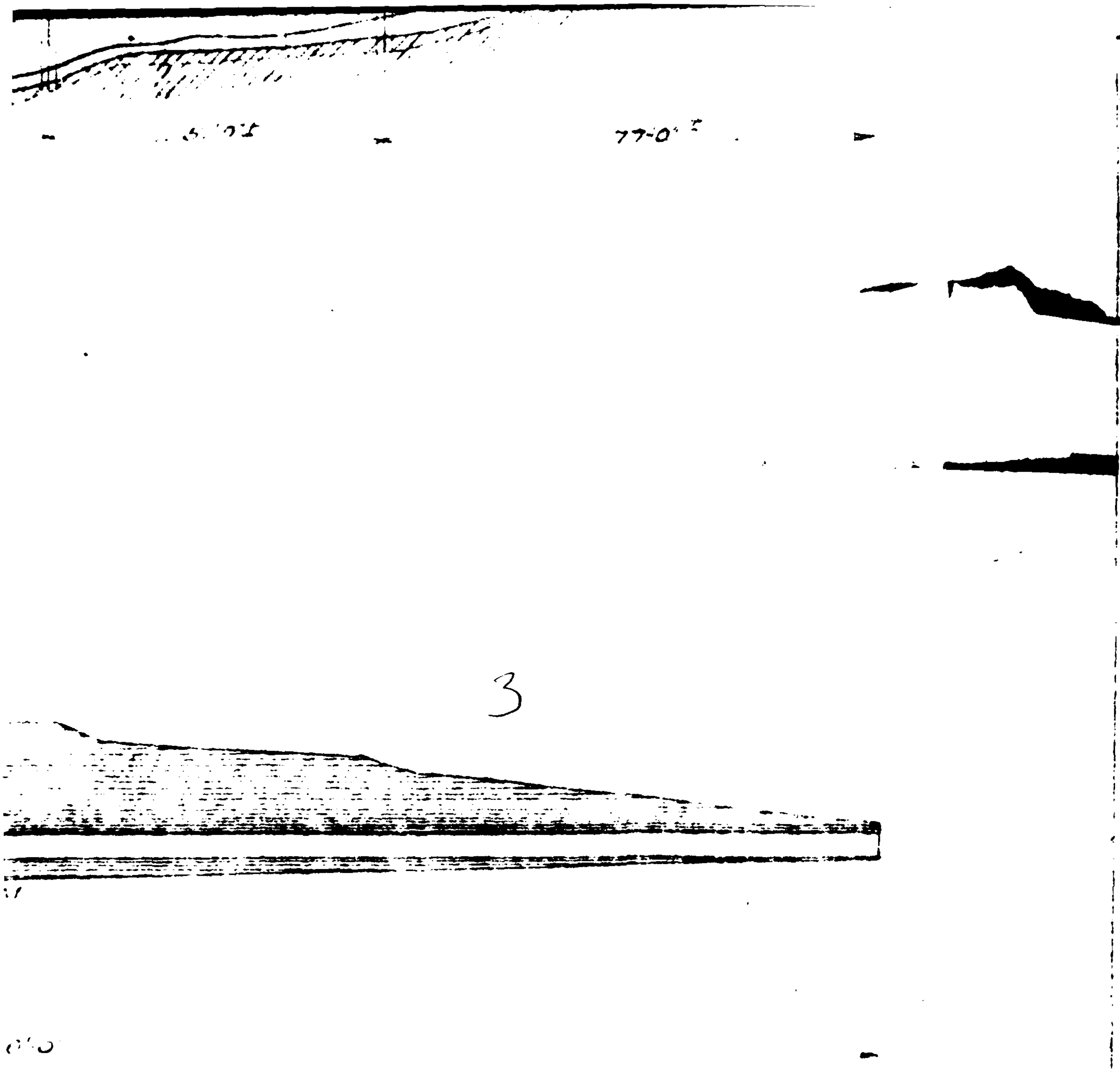
Chief Engineer

Albany N. Y.

This is to certify that by resolution of this Commission ... provisions of Section 22 of the Conservation Law, the above mentioned plans and ... approved.

CONSERVATION COMM

By



...TATE OF NEW YORK
...RVATION COMMISSION
...ION OF INLAND WATERS
Albany, N. Y. Jun 11 1914
...with the accompanying specifications, for ... dam
... have been examined and approved.
Alex Rice McKim
... Docks and Dams
Albany N. Y. ... 19
...of this Commission ... in accordance with the ...
...Law the above mentioned plans and specifications were this day
CONSERVATION COMMISSION
By
... to Commission

DRAWING Nº 104-1

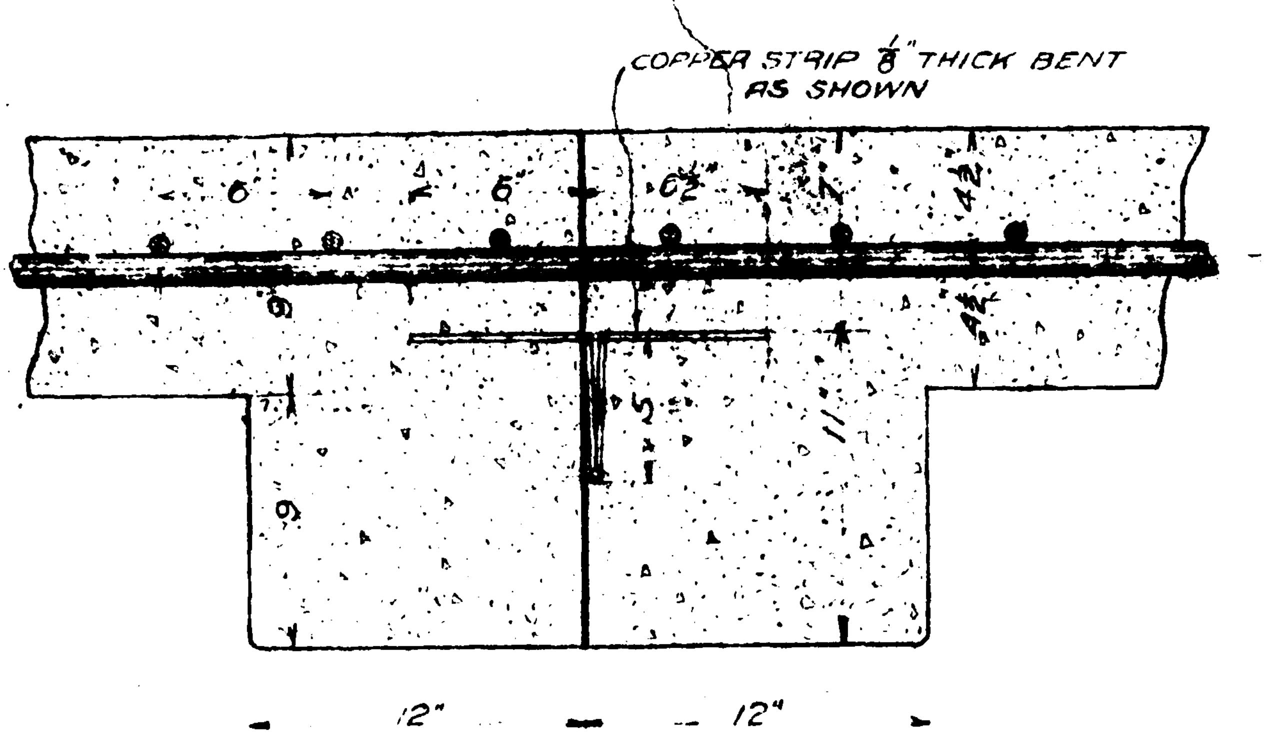
REPAIRS TO CHURCHTOWN DAM
CITY OF HUDSON N.Y.
CHURCHTOWN DAM
PLAN AND ELEVATION

6

Nicholas S. Hill Jr.
Consulting Engineer
100 William St.
New York

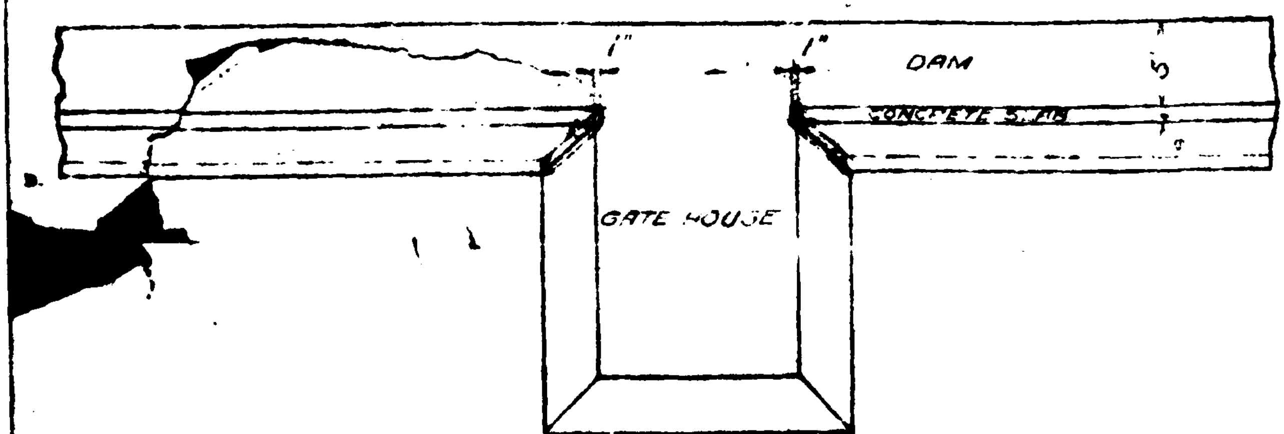
Scale 1" = 20'
Date July ... 1914

Drawn by ...
Checked by ...



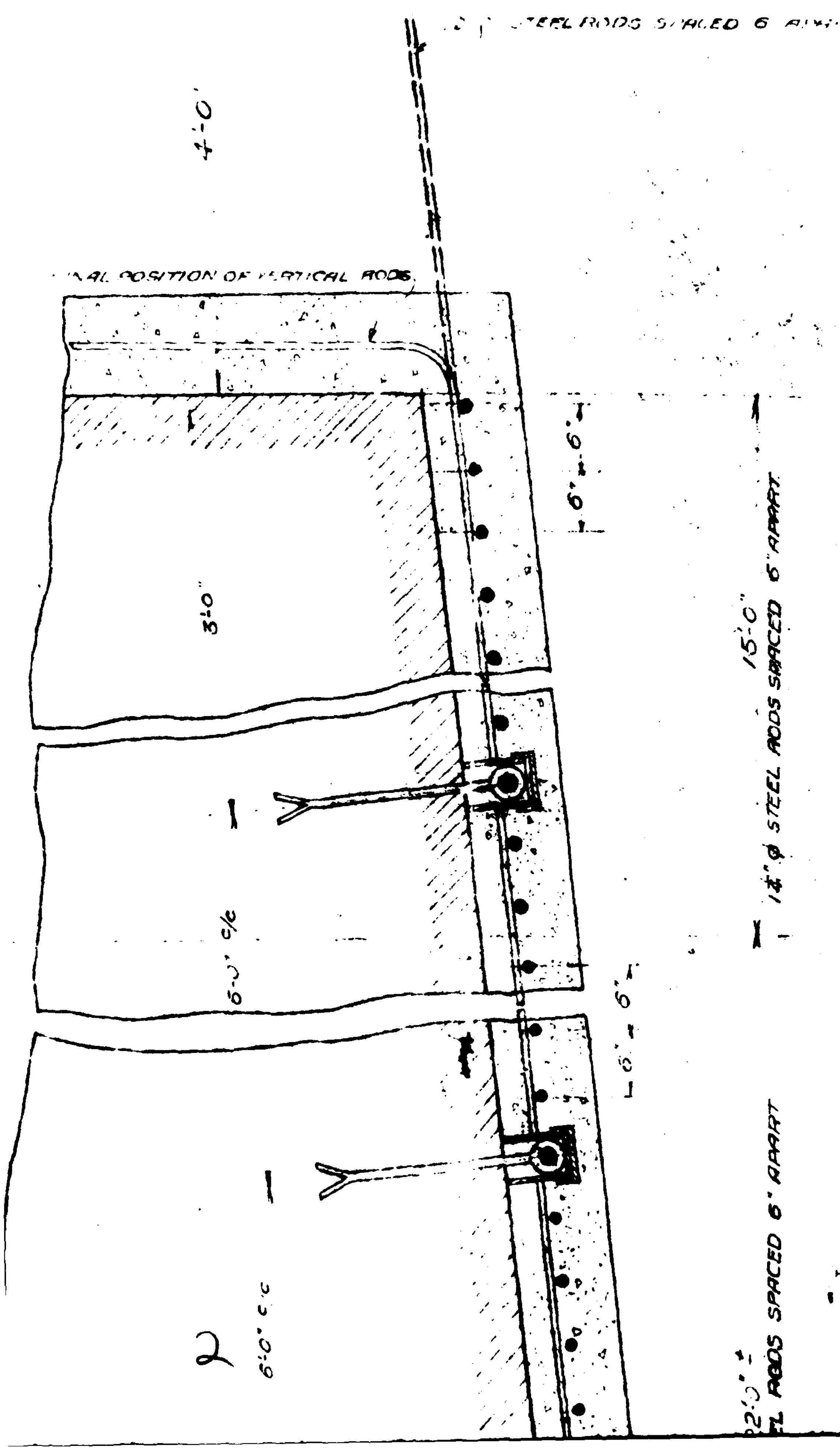
CONSTRUCTION JOINT DETAIL

SCALE 2" = 1'-0"



SKETCH SHOWING CONNECTION OF CONCRETE SLAB AND GATE HOUSE

(NOT TO SCALE)



DETAILS OF REINF

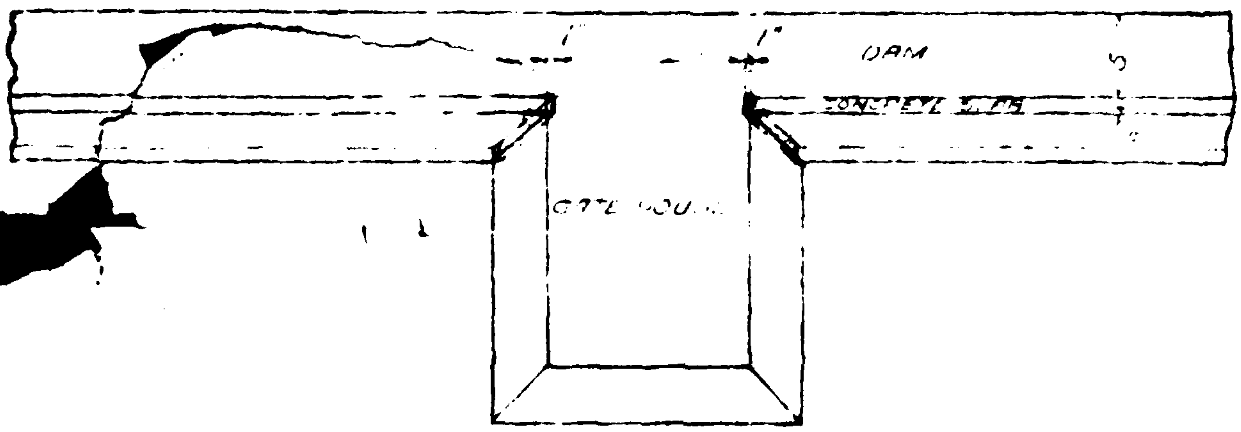
SCALE 1" = 1'-

DETAILS OF REINFORCING 3

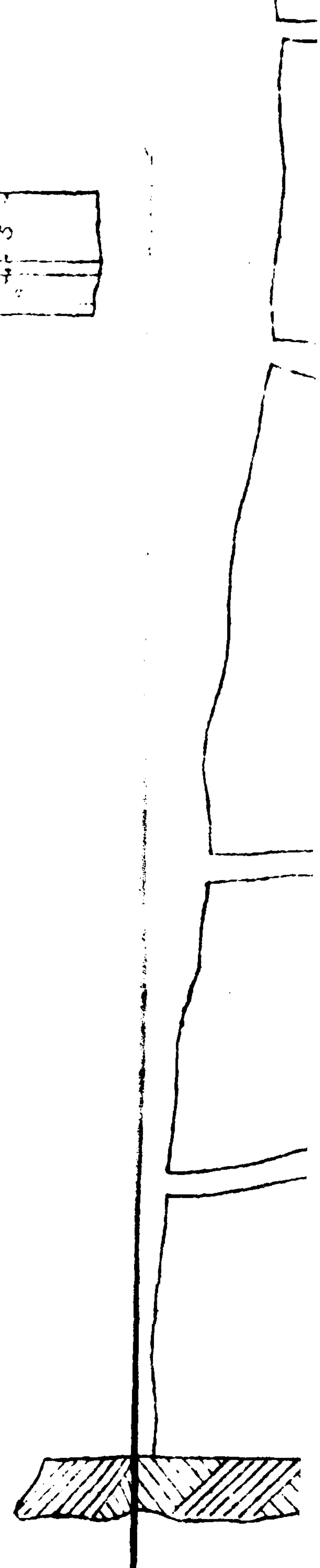
SCALE 1" = 1'-0"

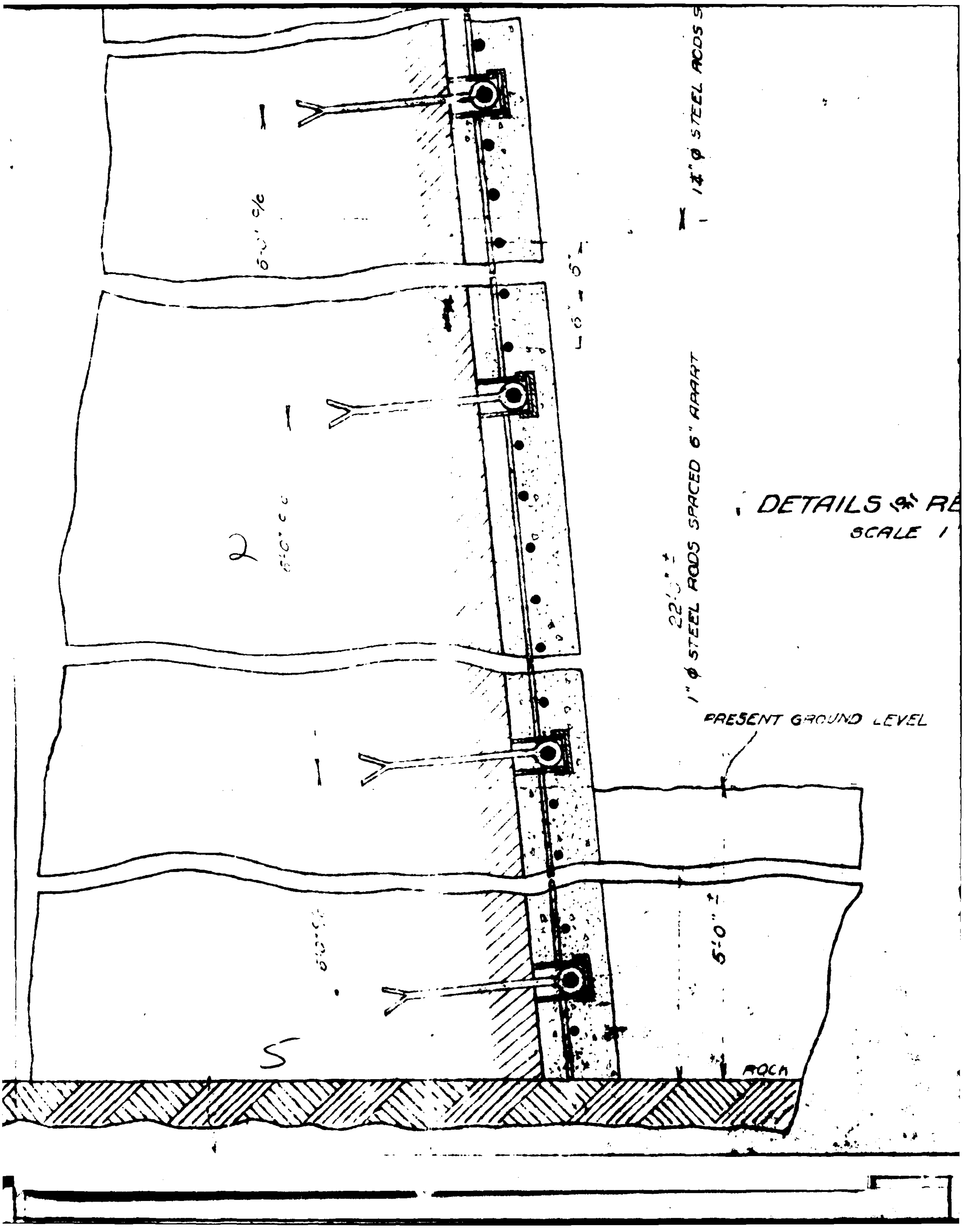
STATE OF NEW YORK
CONSERVATION COMMISSION

ORIGINAL



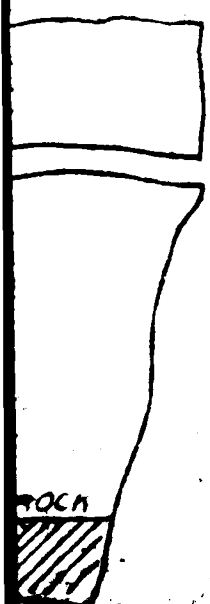
SKETCH SHOWING CONNECTION OF
CONCRETE SLAB AND GATE HOUSE
(NOT TO SCALE)




DETAILS OF RE
SCALE 1"
1¼" φ STEEL RODS S
1" φ STEEL RODS SPACED 6" APART
22'0" ±
PRESENT GROUND LEVEL
5'0" ±
ROCK
6'0" c/c
2
5

DETAILS OF REINFORCING 3
SCALE 1" = 1'-0"

ENT GROUND LEVEL



ORIGINAL

STATE OF NEW YORK
CONSERVATION COMMISSION
DIVISION OF INLAND WATERS

Albany, N. Y., July 11 1914

This is to certify that the plan, with the accompanying specifications, for reconstructing / constructing ... dam (Re 1009 Lower ... dam) Watershed, have been examined and approved.

Chief Engineer.

Alex Rice McKim
Inspector Docks and Dams.

Albany N. Y., ______ 19__

This is to certify that by resolution of this Commission under and in accordance with the provisions of Section ... of the Conservation Law, the above mentioned plans and specifications were this day approved.

CONSERVATION COMMISSION

By ______
... to Commission.

DRAWING № 104-2

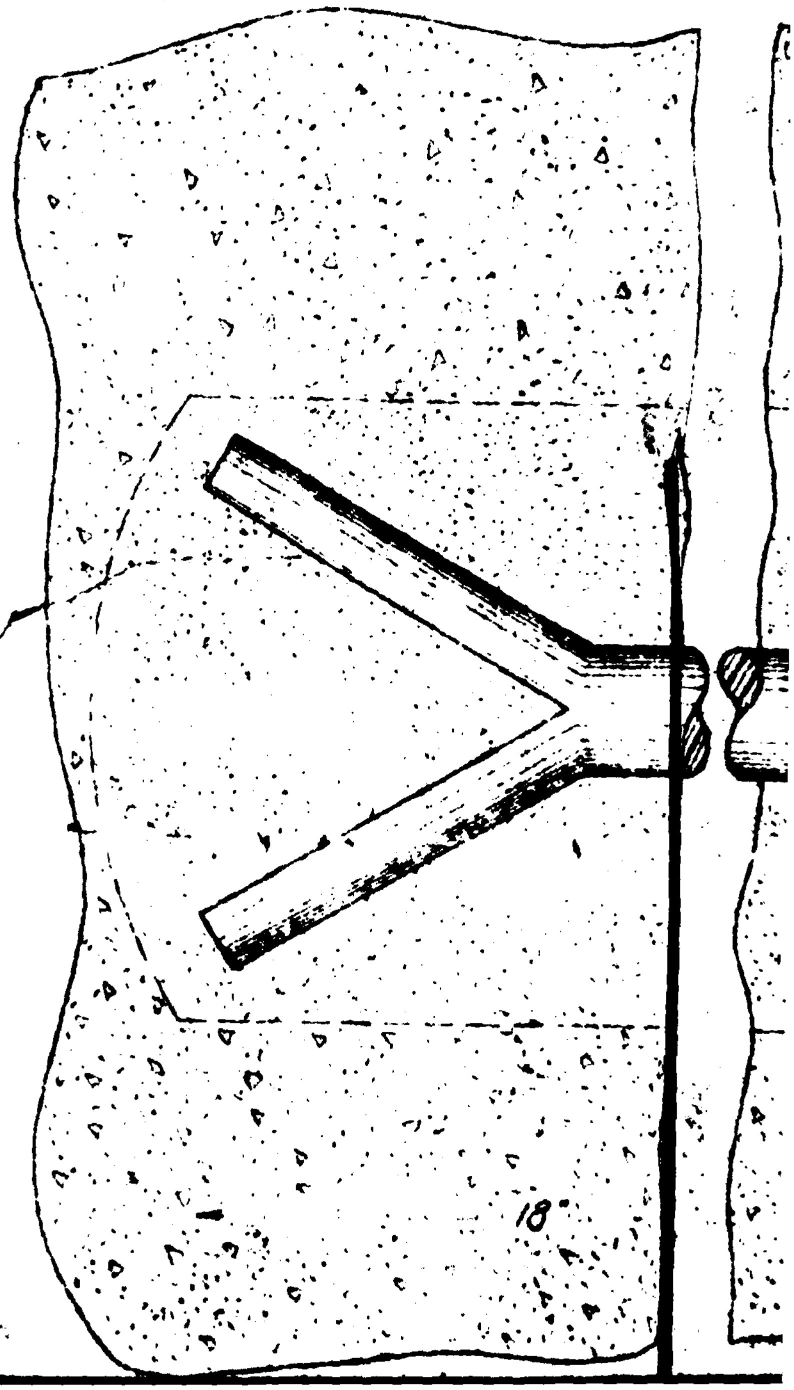
REPAIRS TO CHURCHTOWN DAM
CITY OF HUDSON N. Y.
DETAILS OF REINFORCING
AND CONSTRUCTION JOINTS

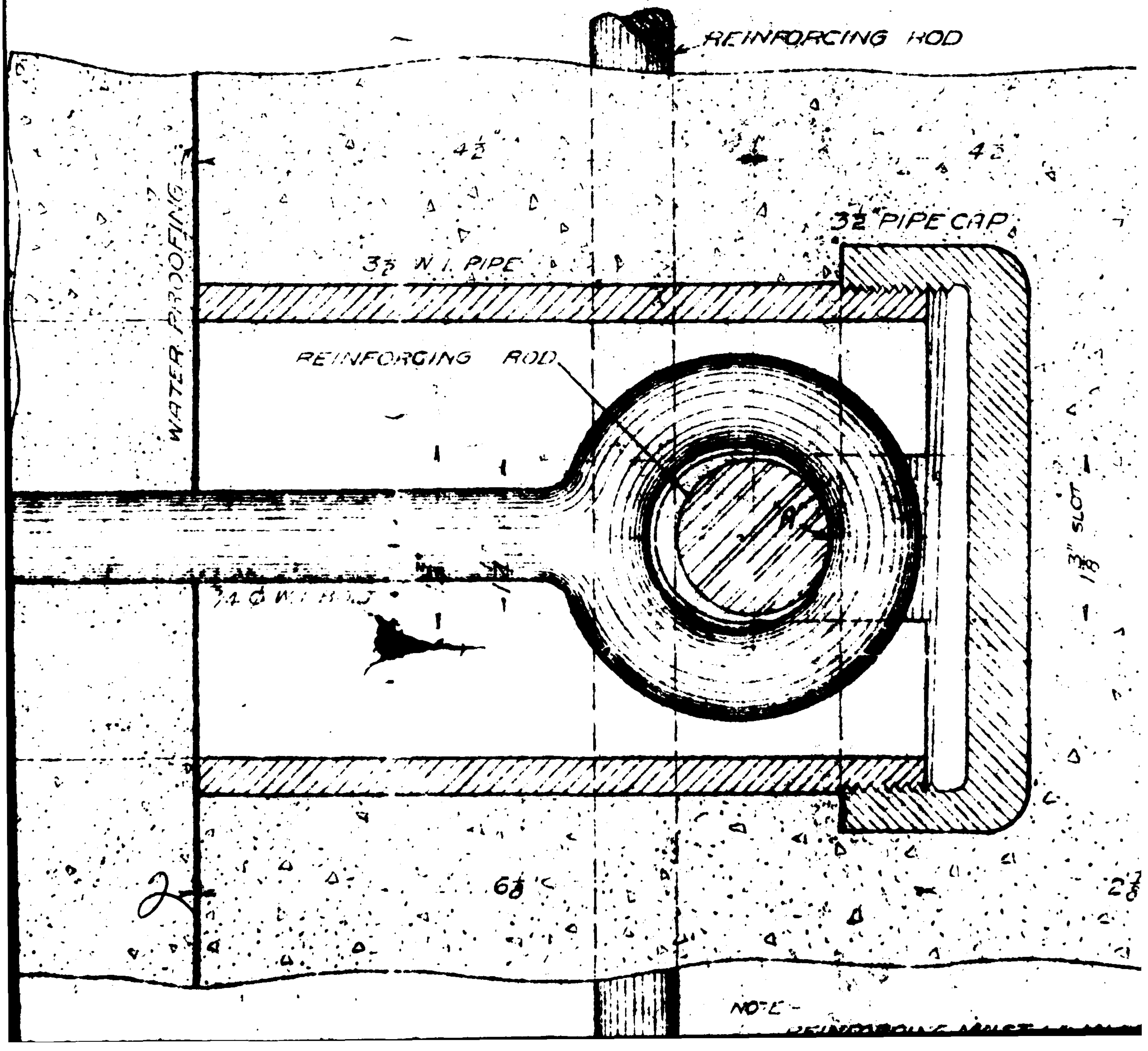
6

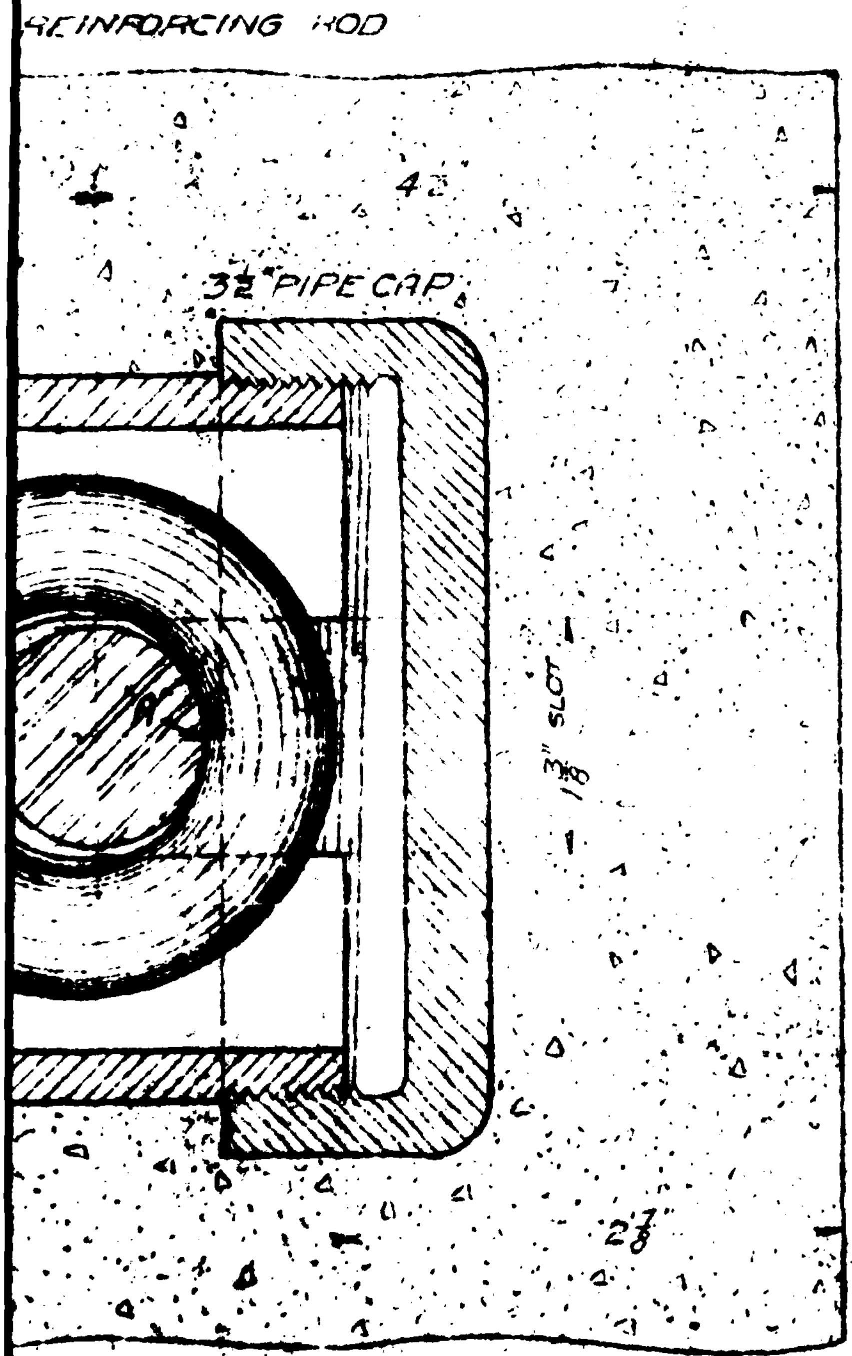
Nicholas S. Hill, Jr.,
Consulting Engineer,
100 William St,
New York.

Scale 2" = 1' & 1" = 1'-0"
Date July 8. 1914

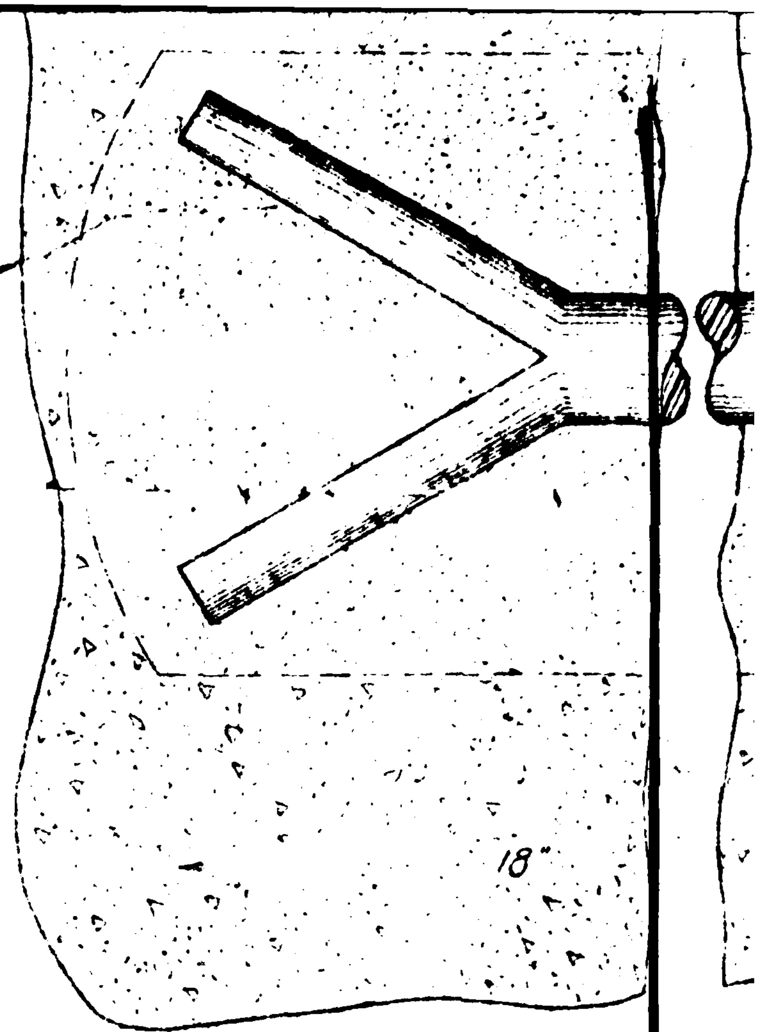
Drawn by C.B.
Checked by ...


18


REINFORCING ROD
$4\frac{1}{2}$
$4\frac{1}{2}$
$3\frac{1}{2}$" PIPE CAP
$3\frac{1}{2}$ W. I. PIPE
WATER PROOFING
REINFORCING ROD
$\frac{1}{8}$" SLOT
$6\frac{5}{8}$
$2\frac{7}{8}$
2
NOTE-



3



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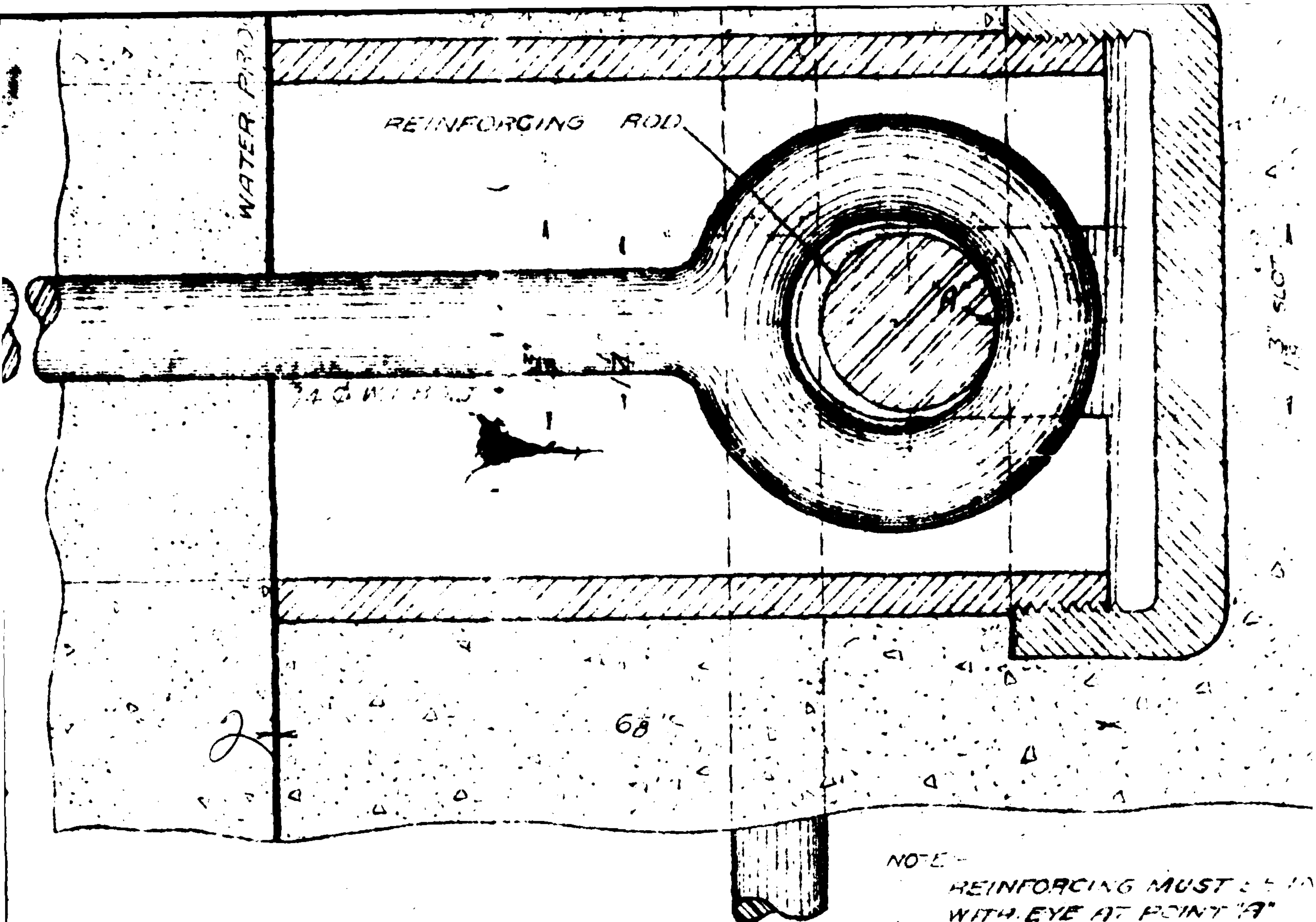


5

7102

STATE OF NEW YORK
CONSERVATION COMMISSION
DIVISION OF INLAND WATERS
Albany, N. Y., ______ Ju

This is to certify that this plan, with the accompanying specifications, fo
for 100' Lon ... Watershed) have been examined

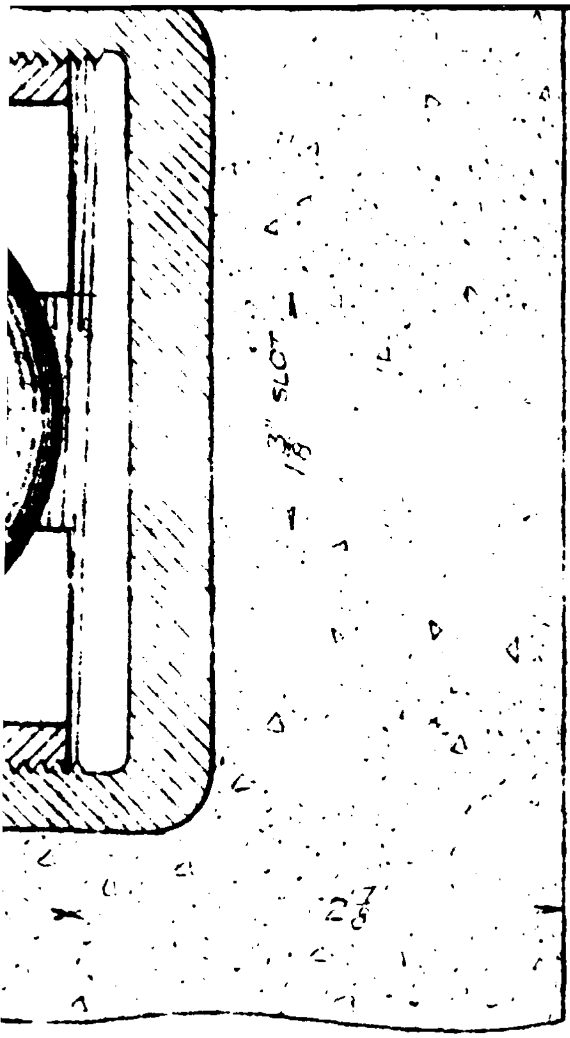
______
Chief Engineer

Albany, N. Y.

This is to certify that by resolution of this commission under and in accord ... of Section 22 of the Conservation Law the above mentioned plans and specifi... approved.

CONSERVATION COM

By ______
Secretary to



3

…ACING MUST … IN CONTACT
…E AT POINT "A"

… OF NEW YORK … ORIGINAL
…TION COMMISSION
…F INLAND WATERS
Albany, N. Y., July 11 1914
… accompanying specifications for reconstructing dam … have been examined and approved.
… Docks and Dams
… CONSERVATION COMMISSION

DRAWING Nº 104-3

REPAIRS TO CHURCHTOWN DAM
CITY OF HUDSON N.Y.
DETAILS OF BOLTS HOLDING
REINFORCING STEEL TO DAM

6

Nicholas S. Hill, Jr.,
Consulting Engineer
Scale F…
Date …
… New York
Drawn by …
Checked by …

END

DATE

FILMED

11-81

DTIC